Why do you do what you do?

What influences students when they are choosing a career in science and do science awareness activities have any effect?

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I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma at any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except when due reference is made in the text. The empirical work described within was not carried out with any other person.

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Abstract

For some time it has been widely recognised that for Australia to guarantee future prosperity, it must have a scientifically skilled workforce and a scientifically aware and/or literate society.

Under the current trends of declining enrolments in secondary and tertiary science, experts are now questioning whether Australia will be able to meet the demands and challenges of the future.

There are many science awareness activities happening in Australia with the aim of reversing this declining trend of science enrolments. However, little is known about how, of if they actually work.

Through the collection of data from first year tertiary science and non-science students, this sub-thesis describes influences on students when they are choosing their career and whether science awareness activities have any effect.

Based on the research findings, conclusions and recommendations for further research have been made.

Acknowledgements

I would like to thank those within the tertiary institutions for their cooperation in collecting the data for this study.

Thanks to my family and friends for their patience and encouragement throughout this 'long-term' project.

Thanks to Dr Sue Stocklmayer for her advice and support.

This work is dedicated to my dad Jack Carr.

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List of Symbols, Abbreviations and Nomenclature

ABC	Australian Broadcasting Corporation
ASTA	Australian Science Teachers Association
ANU	Australian National University
BAA	Backing Australia's Ability
CSIRO	Commonwealth Science and Industry Research Organisation
DEST	Department of Education, Science and Training
DITR	Department of Industry, Tourism and Resources
NIAS	National Innovation Awareness Scheme
OECD	Organisation for Economic Cooperation and Development
PAISIs	Public awareness of science initiatives
PMSEIC	Prime Minister's Science, Engineering and Innovation Council
R&D	Research and development
UCAN	University of Canberra

1 Introduction

Introduction

For some time it has been widely recognised that for Australia to retain its position as an advanced technological society, it must have a scientifically skilled workforce and a scientifically aware and/or literate society. [PMSIEC, 1999] Under the current trends of declining enrolments in secondary and tertiary science, experts are now questioning whether Australia will be able to meet the demands and challenges of the future. [PMSIEC, 1999]

In response to these worrying trends, millions of private and public dollars have been invested in programs that have the broad aim of raising the profile of science amongst Australians, particularity our youth. A more specific and measurable aim of these science awareness programs is to encourage students to study science at a secondary and tertiary level and consequently pursue a career in science.

Science awareness programs place science, technology and innovation in a non-traditional framework that is accessible and attractive to the target audience. For example, science awareness activities in Australia include festivals, exhibitions, theatre, debates, competitions, open days, workshops, art events and much more.

The effectiveness of many of these programs remains unknown. Many programs can boast quantitative outcomes such as audience attendance numbers, media coverage, funds invested and participation figures, but there is little information that can offer insight into outcomes such as behavioural change. For example, are these programs encouraging students to study science at university?

This study will investigate factors that influence student's choices when it comes to choosing a career in science. It will also look at the influence certain science awareness programs have on students. In particular, the study will compare responses from first year science and non-science students in order to identify differences in motivation and factors that have influenced their career decision. By doing this I hope to determine whether science awareness programs are achieving their aim of influencing students to study science.

Background to the study

For the past five years, I have been involved in coordinating science awareness programs targeted at groups as diverse as politicians, primary school students, teachers, parents, scientists, businesses, the public and teenagers. During this time, I have been faced with the challenge of spreading minimal funds across broad target audiences and consequently having few funds left over for evaluation. Although this is not ideal or best practice for implementing communication and awareness strategies, it is the reality for many organisations across the country, and indeed the world.

After talking with colleagues, I calculated that millions of dollars have been spent on increasing science awareness amongst Australia's youth in the hope that they will pursue it as a career. To date, little or no research has been done on the effectiveness of these programs. Evaluating these activities is essential for tailoring existing programs, developing new ones and providing feedback to funding bodies who determine where best to allocate funds.

Statement of the problem

Private and public organisations around Australia are investing in activities aimed to increase the number of students studying science at university. They are doing this because if enrolment trends continue, Australia will be unable to meet the future demands required by a scientifically skilled workforce.

Despite these actions, students are still turning away from studying science, particularly the enabling sciences such as physics, chemistry and mathematics. [Australian Government, 2003] By determining the factors that influence our students when they are choosing their career, we can become better equipped with ways to remediate this worrying trend.

Study approach

This study aims to identify factors that influence and motivate students when they are choosing their career. By examining data collected from a questionnaire, the study aims to discover what influences students to study science, and determine if science awareness activities have any effect.

Research questions

The following research questions were developed for this study:

1. What influences students when they are choosing a career in science?
2. Do science awareness programs influence students to study science?

Method

In order to answer the research questions, data was collected from first year tertiary students in the form of a questionnaire. (Appendix 1) Students were asked to describe reasons and motivations behind their choice of study and rank the influence science awareness activities had on this decision making process.

The data was divided into groups: those studying science and those studying something else; male and female; from the ACT and rest of Australia. Comparisons between groups and correlations within groups could then be determined, and conclusions made.

Conceptual or substantive assumptions

It was assumed that those asked to complete the questionnaire could provide insights into what influences first year tertiary students when they are choosing their career. The data collected from the questionnaires were subjective and related to individual experiences. However, if questionnaires yielded similar data, it was assumed that a trend could be established and more general applications could be made.

Significance of the study

It is hoped that the results of this study will determine what influences students to study science and if science awareness activities have any effect. Science awareness activities are just one part of a larger campaign to reverse the declining trend of tertiary science enrolments, and to date, this type of information has been "patchy" or non-existent.

Limitations

The data was collected from tertiary educational institutes in the ACT, therefore generalisations are limited. The results generated from this study may not be suitable to extrapolate across the country; however similar studies in other states could provide a more accurate picture of what is occurring in Australia.

Overview

Chapter two is a review of related literature. The chapter discusses the importance of the problem to Australia, what we currently know about how students make career decisions and the related science communication issues.

Chapter three describes the research methodology and the methods chosen for data collection, analysis and interpretation. This chapter describes why a questionnaire was chosen as the most suitable means of data collection and how this data was analysed and the results interpreted.

Chapter four presents analysed data for interpretation. Here, the results of the questionnaire are examined and comparisons are made between students studying science and non-science, males and females and in some cases, in state or territory a student completed their final year of high school.

Finally, chapter five presents the conclusions that have been drawn from the analysis of the data and provides recommendations for future science awareness programs and for further areas of research.

2 Literature Review

Introduction

Australians have become familiar with the term 'brain drain'. It has been understood for some time that many of Australia's talented scientists will work overseas, rising through the ranks of prestigious universities or heading up large multi-nationals. [Andrews, 2004]

Conversely, Australia does benefit from 'brain gain', the movement of international scientists to Australia to work and study. On the grander scheme of things, the number of scientists won or lost at the international level is quite small compared to another phenomenon facing Australia; that is "brain loss". [Andrews, 2004]

'Brain loss' is a term used to describe the loss of potential scientists rising through our education system. They may be students who might have chosen to study science, but choose otherwise, or students who choose not to study enabling science such as physics, chemistry or mathematics. They may even be qualified scientists who change career and opt out altogether.

This chapter will investigate why science and technology is important for Australia's economic and social prosperity. It will examine current science enrolment trends at secondary and tertiary levels to determine the extent of Australia's "brain loss". The current thinking as to why "brain loss" occurs will be investigated and initiatives and programs that aim to reverse this trend will be explored.

The relationship between science, technology and national prosperity

For many years, Australia's economic wealth has literally been riding on the sheep's back. Agricultural land and natural resources have traditionally been indicators of Australia's wealth and economic prosperity.

With the establishment of a new economic order over the last several decades, measurement of economic wealth has changed and can now be more accurately measured in the education and skill level of the workforce. International studies confirm that brain-based industries are of increasing economic significance. As competition is increasingly based on product performance rather than price, performance in research and development (R&D) has become increasingly significant. [Lowe, 1999]

A number of economic studies have found there is a clear link between technological progress and economic growth. [PMSEIC, 1999] According to the Organisation for Economic Cooperation and Development (OECD), all technological innovations can be traced back, at least in part, to science and engineering.

Using the US as an example, it is believed that America's economic growth and power in the past two decades has been propelled by science and technology. Former US Federal Reserve Chairman, Alan Greenspan, believes that the unexpected leap in technology is primarily responsible for the nation's record-breaking economic performance. [President's Committee of Advisors on Science and Technology, 2000] This surge can be attributed to the healthy contribution industry makes to R&D in the US, funding 60% and outspending the government more than two-to-one. [Bonvilliam, 2000]

US investment in R&D and its subsequent rise as an economic power shows the important role science, technology and innovation can play in economic prosperity. In Australia, we must not overlook similar outcomes from investment in brain-based industries. An Australian Government (2003) report suggests that science and innovation can provide tools to manage risk, solve complex problems and adapt to change. They can underpin the management of social and environmental challenges such as population ageing, land degradation and soil salinity.

Science, technology and innovation have strongly influenced the economic climate of the past several decades. If this trend is to continue, and there is no evidence to suggest otherwise, it could be concluded that the role science plays in Australia's future will be even greater.

The supply of Australia's scientifically qualified workforce

The demand for scientists is influenced by many factors. Economic growth, technological development, R&D, government priorities and occupational wastage all have an impact. [Borthwick and Murphy, 1998] In a recent address by Queensland's Chief Scientist, Professor Peter Andrews, it was suggested that for Australia to reach the average R&D capacity of leading nations such as Finland, Sweden and Japan, Australia would need an extra 70,000 scientists, preferably post-doctoral, by the year 2010.

Although high, this projection does draw attention to the current state of science enrolments within Australia's education system. Can the future demand for scientists be met?

An Australian Government report on mapping science and innovation showed the long-term sustainability of Australia's skills base in the enabling sciences is under pressure in some areas:

"At a tertiary level, a decline in the number of students completing degrees in maths, health sciences and technologies, engineering, general science and physical sciences has been evident in the latter half of the late 1990's and up 2000." [Australian Government, 2004:43]

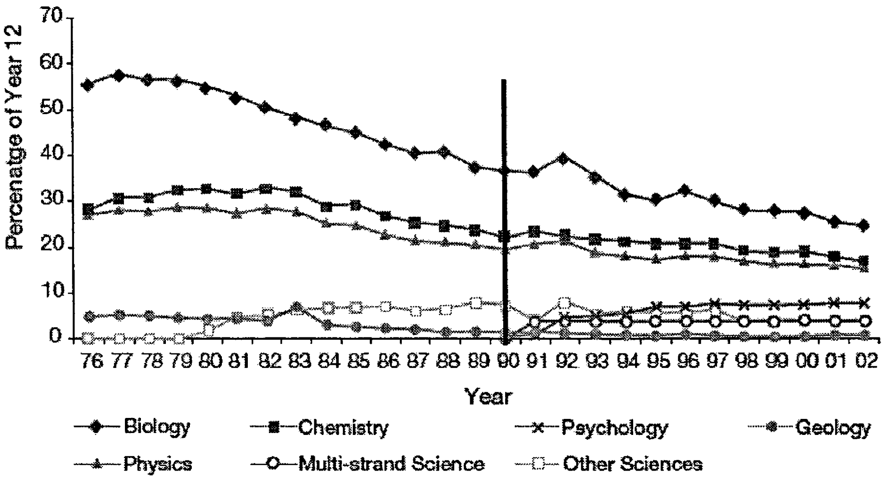
At a secondary level, the number of students choosing to complete Year 12 has doubled between 1980 and 1998. [MCEETYA, 2001] However, the proportion of students studying physical sciences has decreased from 45% in 1991 to 36% in 2000. Similarly, students studying advanced or intermediate mathematics fell from 61% in 1990 to 52% in 1999. [Australian Government, 2003]

Year 12 students traditionally study a combination of physics and chemistry as the basis for entrance into science, engineering or health undergraduate studies. The proportion of students studying this combination declined from 11.4% in 1998 to 9.7% in 2000. [Australian Government, 2003]

The decline in Year 12 science enrolments is even more distinct if we look at the trend over a longer period. Figure 1 shows science enrolment as a percentage of all Year 12 enrolments and depicts a distinct downward trend in biology, chemistry and physics enrolments over a 26 year period (1976 – 2002).

Figure 1 shows that biology, although the most popular science studied in Year 12, has experience a downward trend in enrolments from 58% in 1977 to 25% in 2002. Physics and Chemistry's popularity peaked during 1980, however by 2002, enrolments had steadily declined by 16% and 13% respectively. Enrolments in Psychology and multi-strand science were first taken in 1990. Enrolment in both subjects had stabilised at 8% and 4% respectively by 2002. [Australian Government, 2003:4]

Figure 1 National participation rates among Year 12 students in science subjects from 1976 to 2002



Notes: Data for the period 1990 to 2002 provided by DEST based on information provided from the assessment, curriculum and accreditation authorities in each jurisdiction. Data for the period from 1976 to 1989 taken from Dekkers et al. (1991). Percentages based on ABS Year 12 enrolment statistics: Schools Australia (Cat. No. 4221.0).

[Source: Australian Government 2004:4]

The study of science at the primary level is also facing difficulties. There is evidence to suggest that the interest and enjoyment of Australian students in science activities is decreasing as students move from upper primary to junior secondary school. [Speering and Rennie, 1996]

The education system itself may be failing to capture the interest of our brightest students who would normally make enormous contributions to the future of Australian science. This is a worrying trend considering the number of scientists and science teachers required in this era of new technologies. [Mattick, 2002]

Why is the number of students studying science declining?

There are many factors contributing to the rate of attrition of students studying science. The education system and science curriculum, changing student priorities and influences and the quality of science teaching all have a role to play.

The education system and the nature of the science curriculum contribute to the attrition rate of students studying science. There appear to be three stages where potential science students can be lost or, put another way, not identified and nurtured. These stages are: primary school; the transition from primary to secondary school; and upper secondary where science subjects are no longer compulsory.

Young primary school students are naturally inquisitive, enthusiastic and eager for hands-on activities. In Australian primary schools, these keen students are led by teachers who often have little or no training in science. The proportion of Bachelor of Education or Diploma of Education students taking maths and science has declined from 25.5% in 1991 to 18% in 2000. [Australian Government, 2003] Faced with very little support, resources and competing priorities with numeracy and literacy, there is very little time spent actually teaching science. It is estimated that one hour of science is taught per week in Australian primary schools. [Mattick, 2002]

The transition from primary to secondary school is when students look forward to studying science the most. Unfortunately, expectations are usually not met. [Mattick, 2002] Enthusiastic students are faced with teacher-centred, blackboard directed learning with little opportunities for hands-on participation. As a result, attitude toward science deteriorates between primary and secondary schooling. [Hackling et al, 2001]

In upper levels of secondary school, science is no longer compulsory. Here students choose not to study science because it is perceived to be much more difficult and demanding compared to the many other subjects on offer. Many students feel that the science they have studied bears no relevance to everyday life and has been of no help in making decisions that students felt were important, such as health or the environment. [Mattick, 2002] An Australian study found that:

"Almost 40% of secondary students never got excited about what they do in science and 22% said that they were almost always bored in science." [Hackling et al, 2001:8]

In addition to the factors mentioned above, research has shown that changes in student priorities and influences have played a part in the decline in the number of students studying science. Peer pressure and parental interest, career relevance and jobs, career advice by teachers and lack of role models have been found to turn students away from studying science. [Wood and De Laeter (1986), Woolnough (1994), Dobson and Calderon (1999)]

Australian students are not alone in their changing attitudes toward science. The ROSE project – the Relevance of Science Education [www.ils.unio.no/english/rose viewed 23 June 2006], is a large-scale international project that has examined students attitudes toward science in 40 countries. The report shows that students do not like school science and girls dislike it more than boys. What is even more alarming is that the study has shown that students do not see job opportunities in science; and do not wish to become scientists or want jobs in technology-driven industries.

Darling-Hamond (2000) has demonstrated a clear relationship between quality of teaching and quality of teachers. An Australian Government report examining the future of Australia's teachers suggests:

" a numbers of teachers without adequate specialist backgrounds in science, technology and mathematics are teaching in these areas. The extent to which this is occurring is difficult to analyse as there is no national standard." [Australian Government, 2003:82]

The report also found that recruiting secondary teachers with specialisations in physics, chemistry, maths and technology was difficult in some rural, remote and metropolitan areas. In the second half of 2002, there were national shortages in teachers specialising in maths, physics/chemistry and general science.

In Australia, there is a disproportionate number of male science, maths and technology teachers who are aged 45 or over. [Australian Government, 2003] This seems to be an international trend with the imminent retirement of a large number of experienced teachers. Before the middle of the next decade, serious measures will be needed to attract more teachers with these specialisations.

A study by Hackling et al (2001) found that the quality of science teaching is also limited by inadequate science budgets, poor access to laboratories, inadequate equipment and poor access to computers. The same study found that the undervalued status of teachers within the community, their lack of professional or monetary recognition; under-resourcing and overloading them with non-teacher duties were major factors contributing to the decline in the quality of science teaching. These factors were also responsible for the inability to attract younger, better teachers into the profession.

There are many reasons why students are turning away from studying science. The schooling system and curriculum, changes in student priorities and influences and the decline in the number of qualified science teachers and the quality of science teaching have all contributed to this phenomenon in some way.

Factors influencing career choice

Today there is stiff competition between universities, organisations, governments and industry for qualified graduates. They are all competing to ensure their future workforce needs are met and Australia's knowledge economy remains internationally competitive.

As a result, there is a lot of interest isolating the factors that influence students careers decisions. Here we will examine the role teachers, parents and unplanned serendipitous events have on students' career choices.

Teachers

Studies have shown the important role teachers play when students are choosing their career. Bright et al (2005) suggests that teachers are a major influence on students when they are choosing a career because they directly influence factors such as "subject area, quality of teaching, enthusiasm, time spent with the pupil, and opportunities provided by the subject (site visits, work experience, university visits, visiting speakers and so on)." [Bright et al 2005:21]

Similarly, Munroe and Elsom suggest that

> "Science teachers appeared to have a major influence on pupils' motivation toward and employment in science. This influence was exerted in the following ways: experiences in science classrooms; extracurricular activities initiated by science departments; and information about the content of post-16 courses and strategies for coping with advanced studies." [Munroe and Elsom, 2000:4]

Parents

Studies have shown the influence families, particularly parents, have on career development and choice [Dick and Rallis (1991), Otto (2000), Taylor et al (2004), Bright et al (2005)]. One study suggests:

> "..that adolescents' own aspirations are influenced by their parents' aspirations or expectations for them. When adolescents perceive their parents to have high educational expectations for them, adolescents are likely to have higher aspirations for themselves." [Taylor et al, 2004:1]

The Bright et al (2005) study found that students tended to choose occupations congruent with those of the parents. They found that parental influence lessened over time with students reporting less influence as a function of their education age.

Otto (2000) goes on to suggest that out of all the people students can turn to for help in making career decisions, most turn to their mothers.

Serendipitous/Unplanned events

An added level of complexity in predicting students career choice is the unpredictable. Bright et al (2005) suggests that "Unplanned events were consistently cited as an influence on students' career decision making." The study then goes on to say "the frequency with which unplanned events were cited as influential was high enough for them to warrant much closer research attention". [Bright et al 2005:22]

The Bright et al study also stresses the importance of not overlooking these unplanned events by suggesting that we should implement "Strategies aimed at maximising positive chances experiences and minimising negative ones" [Bright et al 2005:23].

There are many factors influencing students when they are choosing their career, however studies suggest that teachers and parents play a major role in shaping and influencing career decisions. Studies also suggest that unplanned or serendipitous events may also play and important role.

Science awareness programs

The modern-day deterioration of the status of science within the community is an international phenomenon that caused a proliferation of counter-attack initiatives.

Many countries have programs aimed to increase the awareness of science and technology. The South African Agency for Science and Technology Advancement (SAASTA) aims to advance awareness, appreciation and engagement in science, engineering and technology in South Africa. In 2003, the Irish government brought together many of their existing science, technology and innovation awareness activities. This new integrated program, called Discover Science and Engineering, aims to have a coordinated approach to increasing the interest in science and to encourage young people to consider science as a career. The British Government also funds a number of activities. For example, the British Association for the Advancement of Science works throughout Britain to promote understanding and development of science, engineering and technology and to illuminate and enhance their contribution to cultural, economic and social life. There are many other publicly funded science awareness activities occurring across Europe, including Public Awareness of Science and Technology in Austria and Germany's Science in Dialogue.

Backing Australia's Ability – Building our Future through Science and Innovation is Australia's over-arching science and innovation package totaled $5.3 billion over seven years from 2004-2011. This package, announced by the Prime Minister on 6 May 2004, builds on the initial 2001 *Backing Australia's Ability* investment of $3 billion over five years to 2005-06. Together these packages constitute a ten year, $8.3 billion funding commitment stretching from 2001-02 to 2010-11.

The Science Connections Program (SCOPE), funded under *Backing Australia's Ability*, aims to increase awareness of the important role science, technology and innovation play in ensuring the well-being of our society and the environmentally sustainable growth of our economy; highlight the outstanding contributions to science and science education made by our researchers and science teachers; and to encourage our young people to consider continuing studies in science, mathematics and engineering beyond the compulsory years of schooling, and to consider entry into science-based careers. SCOPE supports a range of initiatives encouraging interest and engagement in science, engineering, and technology. [https://sciencegrants.dest.gov.au/NIAS/Pages/Home.aspx viewed 23/2/06]

The proliferation of publicly funded science awareness programs across the globe highlights a worldwide trend of governments investing in the knowledge economy to lift their economic and social position. One of the common components of this investment is directed at young people to encourage the pursuit of a career in science.

Youth Oriented Science Awareness Programs in Australia

Many organisations around Australia invest in science awareness initiatives directed at youth with the aim of reversing the current trend of declining enrolments in science. These initiatives are in a variety of formats including science events and festivals, television and radio programs, science publications and science centres. The following examples are only a sample of the different types of activities and have been selected for the purpose of the research; they are by no means exhaustive.

Science events

National Science Week is an annual celebration of science, technology and innovation where universities, science centres, schools, private organisations, local governments, museums and industry present science events. In 2003, 1,224 public events and 1,383 events in schools were delivered during August. Events included exhibitions, open days, workshops, forums, science drama, guided walks, hypotheticals, debates, experiments and science shows. The audience were primarily comprised of school students and the general public. [ASF Limited Annual Report, 2003]

The Australian Science Festival aims to take science to society through the delivery of informative and fun events. During the Festival over 150 events are presented in and around Canberra. In 2003, 54 schools visited the Amazing World of Science, the festivals youth focal point. [ASF Limited Annual Report, 2003] The Amazing World of Science is a hub of activity where youth oriented workshops, talks, science shows and hands-on exhibits are delivered.

Sleek Geek Week is a science comedy show presented by science personalities Dr Karl Kruszelnicki and Adam Spencer. The show explores the quirky and weird elements of science in a fast-paced and fun way. In 2004, Sleek Geek Week presented 11 shows in city and regional locations across Australia. Sleek Geek Week is a popular show with both adults and children that regularly sells out venues.

Science Broadcast

The Australian Broadcasting Corporation (ABC) contributes a significant proportion of the amount of science broadcasted locally and nationally. The ABC has 16 television, 9 radio programs and 21 on-line initiatives with a science theme or which cover science topics. For example, Catalyst is a half-hour weekly television show dedicated to science, technology and innovation. The Lab (www.abc.net.au/science) is the online gateway to all ABC science coverage.

Dr Karl Kruszelnicki is popular science personality who appears on both radio and television. Dr Karl has a regular science show aired nationally on ABC's Youth network, Triple J.

Totally Wild is a popular children's television program which explores many aspects of science. CSIRO jointly produce one half-hour segment every week that feature CSIRO scientists explaining their work together with activities to try at home. Totally Wild has a weekly audience of over 400,000 people. [CSIRO Annual Report, 2004 – 2005]

Science Clubs

CSIRO, Australia's largest research organisation, operates a range of science projects which aim to, among other things, encourage students to take up careers in science, engineering and technology. One of CSIRO's longest running science projects is the Double Helix Club. For 20 years, the Club has inspired hundreds of thousands of young Australians to explore science. Members of the club receive magazines, discounts, email newsletters and membership to CSIRO Science Centre events.

The Helix Magazine is one of CSIRO's bi-monthly publications written to appeal to students over the age of ten. The magazine covers all aspects of science through feature-length articles, competitions and science activities that can be performed at home.

Science Centres

There are ten science centres in towns and cities around Australia. The centres combine science education with entertainment to provide a fun and interactive learning environment. Questacon – The National Science and Technology Centre, was opened in Canberra in 1988. During 2003 – 2004, 1 328 921 people visited Questacon exhibitions and programs. [Questacon Annual Report 2003 – 2004]

CSIRO has a science centre located in Canberra called the CSIRO Discovery Centre. Located within the CSIRO's Black Mountain research facility, the centre showcases Australian science and technology using interactive exhibits. During 2004 - 2005, 58 400 people had visited the centre, including 17 680 school visitors. [CSIRO Annual report 2004 – 2005]

Science Communication issues

Evaluation of science awareness programs

Evaluation of science awareness events is lacking in Australia, and abroad. Gascoigne and Metcalfe recognised this weakness after an informal meeting at the World Conference on Science in 1998 where it was "recognised that current evaluation processes were a weakness in many programs and projects designed to increase public communication of science and technology." [Gascoigne and Metcalfe, 2001:67]

It seems that little has changed since 1998. An investigation on the outcomes of European public awareness of science initiatives in 2004 suggested that, "...in Europe, at least, very little evaluation is currently carried out and reported publicly." [Edwards, 2004:268]

There is no doubt of the benefits associated with evaluating science awareness programs. Evaluation provides purpose and direction to programs and proves they are worthwhile. Evaluation allows the sharing of successful initiatives and minimises the repetition of ones that are not. Evaluation shows the value of the program to participants, organisers, sponsors and colleagues. Why then, are so few programs evaluated?

Sponsors requiring immediate, cheap and quantitative feedback drive 'superficial' evaluation. Funding bodies want to know how many people were exposed to their logo so they can justify their investment. Gascoigne and Metcalfe's study found that ". . .evaluation was not a fundamental design element of the programs, and the organisers relied on superficial measures such as attendance at events to justify their programs." [Gascoigne and Metcalfe, 2001:76] This is demonstrated by the outcomes of National Science Week, which are evaluated in event and audience numbers. Although National Science Week is Australia's largest science awareness program, little is known of the experience the audience had, why they attended events or if their awareness or attitude toward science changed after taking part.

The financial, time and resource cost of evaluation is also a major element influencing the extent to which it takes place. Edwards report found that in Europe, ".so many initiatives, particularly Science Week, are organised and staffed by volunteers with already full workloads". [Edwards, 2004:270] The same is true in Australia. In 2003, over 15,000 hours were volunteered to coordinate National Science Week events. [ASF Limited Annual Report, 2003] As Edwards points out "It is asking a lot of these people for the event simply to be staffed. To ask them to also put resources into evaluation is just out of the question." [Edwards, 2004:270]

For many science awareness programs, it is almost impossible to prove the link between cause and effect. How do you prove it is the program and not some outside influence that caused a certain effect? The difficulty in proving this association is largely due to the lack of clear performance indicators and baseline data. [Gascoigne and Metcalfe, 2001]

Summary

From the review of literature it has emerged that Australia, like many other countries around the world, has realised the important role a knowledge-based economy has on economic prosperity. However, for Australia to reach its potential, it will require a scientifically qualified workforce and a society that is scientifically aware. Based on current enrolment trends in science at a secondary and tertiary level, Australia is at risk of not being able to meet the requirements necessary to become an internationally competitive knowledge-based economy. There are many science awareness activities happening in Australia with the aim of reversing this declining trend of science enrolments, yet very little is known about the effectiveness of these programs.

Consequently, the following research questions have emerged:

1. What factors influence students when they are choosing a career in science?
2. Do science awareness activities influence students to study science?

The next chapter describes the way in which data was collected to answer the research question. It describes why a questionnaire was used and how the data was treated and analysed so that it would provide meaningful answers to the research questions.

3 Research Methodology

Introduction

The literature review highlighted that Australia needs more students studying science and to help achieve this, there are many science awareness programs taking place. However, little is known of the effect these programs are having on students choosing their careers. To determine what influences students when they are choosing their career in science, and if the science awareness programs are having any effect, it is important to seek information from the students themselves. This chapter describes the reasons for choosing a quantitative research approach, the instrumentation and how the data was collected and analysed. This chapter will also review the limitations imposed by choosing this style of research.

Research Methodology

The review of related literature exposed gaps in our knowledge of factors influencing students when they are choosing their careers, particularly students choosing a career in science, and whether science awareness programs effect this decision making process. As a result, the following research questions evolved:

1. What factors influence students when they are choosing a career in science?
2. Do science awareness activities influence students to study science?

Qualitative research could be used to address the knowledge gap stated above, however, it was decided that a larger, representative study take place to provide a basis upon which further, more in-depth qualitative research could be based.

Leedy and Ormrod describe this type of quantitative research as descriptive quantitative research because it "..identifies the characteristics of an observed phenomenon or explores possible correlations among two or more phenomena. In every case, descriptive research examines a situation *as it is.* It does not involve changing or modifying the situation under investigation, nor is it intended to detect cause-and-effect relationships." [Leedy and Ormond, 2001:191]

Because a survey can look closely at a phenomenon of the moment, it was decided that this would be the most appropriate way of collecting the research data. After considering the different ways a survey could be carried out, a paper-pencil, self-completion questionnaire was used because it was cost-effective, efficient and convenient way to collect significant amounts of information in a short period of time, and there would be an absence of interviewer effects and variability. [Bryman, 2004]

Instrumentation

Data was collected in the form of a four-page, self-completion questionnaire given to students at three tertiary institutes in the Australian Capital Territory (ACT), Australia. The questionnaire was administered to students during class-time over the last two weeks of October 2003. This time was chosen because it would cause the least disruption to classes as many were already in revision mode, and in some cases, time had been allocated for students to fill out end-of-term evaluation surveys.

Participating students were reminded that it was not compulsory to fill out the survey. They were also asked to put their initials at the top of the document if they agreed to share this information for the purposes specified. Surveys returned without initials were not used.

The questionnaire was made up of a combination of checklist responses and a rating scale which was used when a "..behaviour, attitude or other phenomenon of interest needs to be evaluated on a continuum." [Leedy and Ormond, 2001:197] Where appropriate, there was opportunity for students to provide additional or alternative responses. A sample of the questionnaire can be found in Appendix 1.

"To ensure internal validity of a research study, we need to take whatever precautions we can to eliminate other possible explanations for the results we observe." [Leedy and Ormond, 2001:105] Measures were taken to ensure the validity and reliability of the data collected from the questionnaire by:

- changing the order of repeated variables on the questionnaire,
- validating rating scale responses by asking for checklist or ranking response to similar questions,
- avoiding respondent fatigue by keeping the questionnaire short with few open ended questions,
- having an easy-to-follow design that minimises the risk of respondents inadvertently missing a question.

Sample Population

First year students from tertiary educational institutes were chosen to be the subject of the study because their experience in choosing their career would be the most recent. The students surveyed were studying at three different tertiary institutes within the ACT. These institutes were chosen for convenience, as the author resided in the ACT at the time the study took place.

An attempt was made to have a balance of responses from both science students and student from other disciplines such as arts, economics and law. However, due to the voluntary nature of the study an even distribution of science and non-science students could not be guaranteed. Table 1 shows the Faculties and Divisions that were contacted to take part in the study, and whether they participated. It is not known why the ANU's Faculty of Arts and Law, and CIT's Faculty of Science and Technology did not take part. Due to time constraints, there was little chance for follow-up and it was decided to continue the study without them.

Table 1 Tertiary institutes invited to participate in the study

Institute	Faculty or Division	Response
Australian National University	Faculty of Science	Participated
Australian National University	Faculty of Arts	Didn't participate
Australian National University	Faculty of Law	Didn't participate
University of Canberra	Division of Health, Design and Science	Participated
University of Canberra	Division of Communication and Education	Participated
Canberra Institute of Technology	Faculty of Science and Technology	Didn't participate
Canberra Institute of Technology	Faculty of Communication and Community Service	Participated

Data Collection Procedures

In August 2003, a letter was sent to selected Deans and Pro-Vice Chancellors of the Australian National University (ANU), University of Canberra (UCAN) and Canberra Institute of Technology (CIT). This letter asked for their cooperation in the study by giving permission and providing details of lecturers who would be interested in implementing the questionnaire within their class. This original contact stressed that it was not compulsory for anyone to assist or take part in the study.

The following Divisions and Faculties were involved in the study:

- Faculty of Science, ANU
- Division of Health, Design and Science, UCAN
- Division of Communication and Education, UCAN
- Faculty of Communication and Community Services, CIT.

From this initial contact and follow-up phone call, a number of lecturers came forward offering their assistance. A confirmation phone call was made to these lecturers to discuss the questionnaire, and the best way of implementing it in their class. Depending on the circumstance of the class, and what best suited the lecturer; the questionnaire was implemented in one of two ways:

1) the author personally addressed the class, distributed and collected the questionaries at the beginning of the class or
2) the author delivered the questionaries to the lecturer who then addressed the class, distributed and collected the questionaries on my behalf.

Students were briefed on how the information they provided would be used to help complete the author's post-graduate studies and it was not compulsory to participate. The students were also asked to initial the survey in the designated place if they agreed for the information contained in the survey to be used in the manner in which it was intended.

To ensure external validity of the research data, it was examined to determine if it was a representative sample of the student population. "Ideally, we want the participants in a research study to be a representative sample of the population about which we wish to draw conclusions." [Leedy and Ormond, 2001:105] To do this, comparisons were made between the research data collected and the official data provided from the statistical units of each university.

Table 2 compares ANU research data and student enrolment statistics for first year students in Semester 2, 2003. In the majority of categories, the research data and the university data is comparable barring a few exceptions that require explanation.

There is a discrepancy between the proportion of overseas students in the research data and the ANU Student Enrolment Statistics. This may be due to the smaller sample size of the research data. This demonstrates a weakness in the research data that needs to be taken into consideration when analysis is made.

Table 2 Comparison between research data and student enrolment statistics ANU, 2003. Source, ANU Statistical Services [www.unistats.anu.edu.au viewed 24 July 2004]

Category	Research Data (%)	Australian National University Student Enrolment Statistics (%)
GENDER		
Male	42	47
Female	58	53
STATE OF ORIGIN		
ACT	57	54
Other Australian state/territory	30	26
Overseas	13	21
AGE		
18-25	98	89
26-35	1	7
31+	0	5

Similarly, the proportion of students in both the 26-35 and 35+ age groups do not reflect the ANU Student Enrolment Statistics. As the majority of the science awareness activities assessed in this study are targeted at school leavers, data collected from students above the age of 26 will not be included in the analysis.

Table 3 compares UCAN research data and student enrolment statistics for first year students in Semester 2, 2003. Like the data from ANU, in the majority of categories, the data collected from UCAN reflects that of the student population.

However, in the case of state of origin, the research data collected does not reflect the proportion of students originating outside of the ACT and overseas. This needs to be taken into consideration when analysing the data.

Table 3 Comparison between research data and student enrolment statistics UCAN, 2003. Source: UCAN Planning and Resource Development, Gerald Tarrant [gkt@adminserver.canberra.edu.au]

Category	Research Data (%)	ANU Student Enrolment Statistics (%)
GENDER		
Male	36	41
Female	64	59
STATE OF ORIGIN		
ACT	49	58
Other Australian state/territory	43	29
Overseas	8	14
AGE		
18-25	77	75
26-35	14	16
31+	9	9

For the purpose of this research, the UCAN research data generated from students aged 26 and above will also be disregarded for the same reasons as above.

In total, 488 questionaries were used to compile the data for this study. The breakdown of the characteristics of the sample population can be found in Table 4.

Table 4 Summary of research data collected

		Choice of study		Completion of final year of high school			Type of science studied		Tertiary Institute attended		
Sex	Total Sample	Science	Non-Science	ACT	Other Australian	Overseas	Biological Science	Physical Science	ANU	UCAN	CIT
Male	182	129	52	90	67	25	90	40	94	85	3
Female	306	210	96	174	107	24	170	40	132	150	24
TOTAL	**488**	**339**	**148**	**264**	**174**	**49**	**260**	**80**	**226**	**235**	**27**

Data processing and analysis

For referencing purposes, each completed questionnaire was allocated a unique number. The data was coded and the response to each variable was entered into an Excel spreadsheet.

The data was divided into the following groups depending upon the responses made in the survey:

- **Male:** responded positively in the male checklist box
- **Female:** responded positively in the female checklist box
- **Science:** responded positively in the "Biological Science", "Physical Science", "Engineering" or specified another science discipline in the "Other" checklist box.
- **Non-Science:** responded positively to the "Business/Economics", "Arts" or specified another "arts" discipline in the other checklist box.
  Note: if a response indicated both science and non-science it was put under the variable that was indicated in the checklist.
- **ACT:** responded positively to the "ACT" checklist response
- **Other Australia:** responded positively to the "NSW", "QLD", "VIC", "SA", "TAS", "WA" or "NT" checklist response
- **Overseas:** responded positively to "Overseas" checklist response

Some groups were further divided down into sub-groups:

- Males were divided down into **Science Male** and **Non-Science Male**
- Females were divided down into **Science Female** and **Non-Science Female**

Within the groups and sub-groups, the response for each variable was counted and added to the spreadsheet. For example, in the Science group, the number of people who responded that Friends had a "Very strong influence (1)" on them when they were choosing their course of study was counted. Similarly, the number that responded Friends had "Strong influence, (2)", "Some influence, (3)", "Little influence, (4)" and "No influence, (5)" were also counted. This technique was applied to each variable in each question.

Initially, attempts were made to statistically analyse the data. In particular the author was interested in determining if any correlations existed between variables. This did not prove successful because of the limitations in which the data was collected. So to interpret the data, the rating scale was collapsed from a five-point scale to a two-point scale. That is, responses of 1 – 4 were said to have "some influence" and a response of 5 was said to have "no influence."

Only the data from those who had attended a science awareness program was used to determine its level of influence. The same two-point scale, as described above, was used to describe the level of influence as described above. For example, to determine the influence Dr Karl had on students studying science, the information from those students who had seen or heard him in the last two years was used. It was assumed that if you hadn't participated in a science awareness program, then it could not influence your choice of study.

Limitations on methodology

There are a number of limitations to the research methodology described above. First, because it was voluntary for faculties to take part, there is a lack of information from students studying business, law or economics. This needs to be taken into consideration when the non-science data is used to describe a population of students not studying science.

Second, the data was collected from ACT institutions only. Ideally, data would have come from a number of institutes across the country. This needs to be taken into consideration when drawing conclusions from the data.

Third, the majority of questions on the survey had set variables, with no room to add personal information. For example, the factors that influenced career choices, along with the science awareness projects, were all prescribed. Therefore, it's not known if the researcher has overlooked an influential factor or science awareness program by not including it in the questionnaire.

And finally, due to the nature of the questionnaire, there is no room to prompt or probe for further information. As discussed at the beginning of this chapter, the purpose of this study was to provide information on how things are, and to open the way for further research to determine why they are this way.

Summary

The chapter discussed how a quantitative research method was chosen because it would adequately investigate the knowledge gap uncovered by the literature review. The choice to use a self-completed questionnaire meant that a large, representational population could be surveyed to provide information on how the situation is now and provide the basis for further investigative research in the future.

Of course this type of research method comes with a number of limitations, which have been identified, along with strategies used to protect the integrity and the validity of the data.

The next chapter reports on the finding of the quantitative research described above.

4 Research Findings

Introduction

This chapter reports on the finding of the descriptive quantitative research described in Chapter 3. In October 2003, first year tertiary students provided data, in the form of a questionnaire, on what motivated and influenced them when they were choosing their course of study. The respondents also provided data on whether they were aware, had attended or were influenced by science awareness programs.

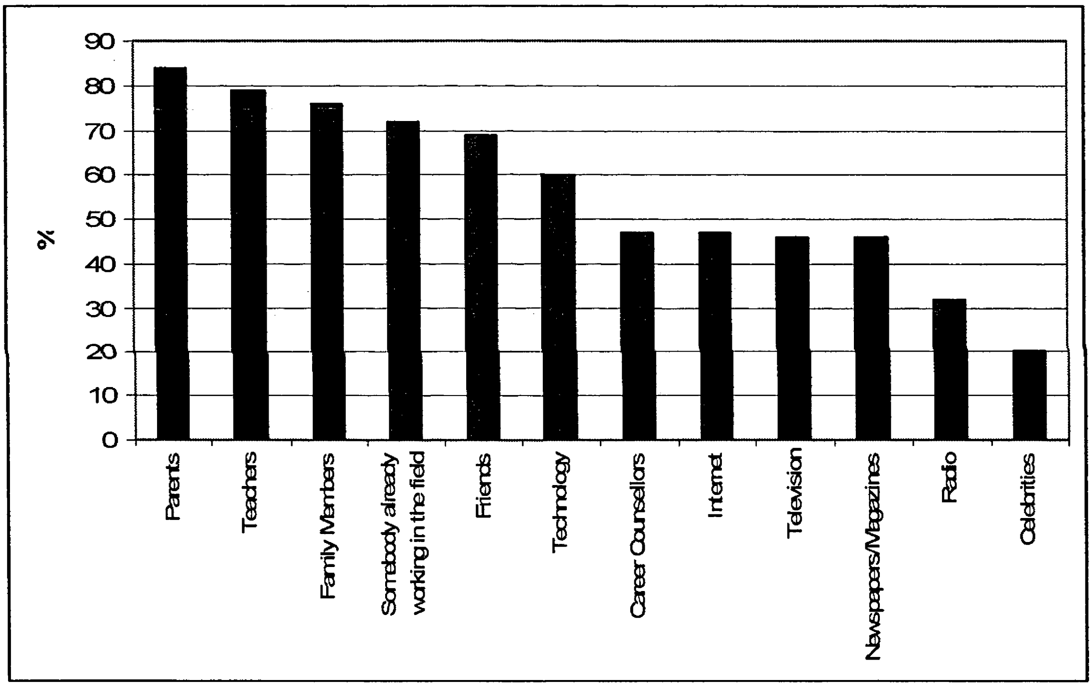
This chapter is divided into two parts. First, it will examine factors that influenced first year students when they are choosing their course of study, and where possible, compare these results to other published studies. Second, it will examine the awareness and participation of students in science awareness programs, and whether the programs influenced their career choice and consequent course of study.

Factors that influence students choice of study

It has been established for some time that parents and teachers strongly influence students when they are choosing their careers. [Bright et al, 2005] Taylor et al (2004) suggests that without parental approval and support, students are often reluctant to pursue, or even explore, diverse career possibilities. This study supports these findings with parents and teachers being ranked the most influential on students when they are choosing their career. Family members and somebody already working in the field also influenced student's choice of study with 76% and 72% of students reporting an influence respectively (Figure 2).

This study also found that students are more influenced by personal relationships and interactions, such as those described above, compared to non-personal factors like the media and technology. Career Counsellors were the exception, having less influence on students than other personal factors described above. Celebrities were ranked the least influential of all factors with 20% of students reporting they had some influence (Figure 2).

Figure 2 Factors influencing student's choice of study

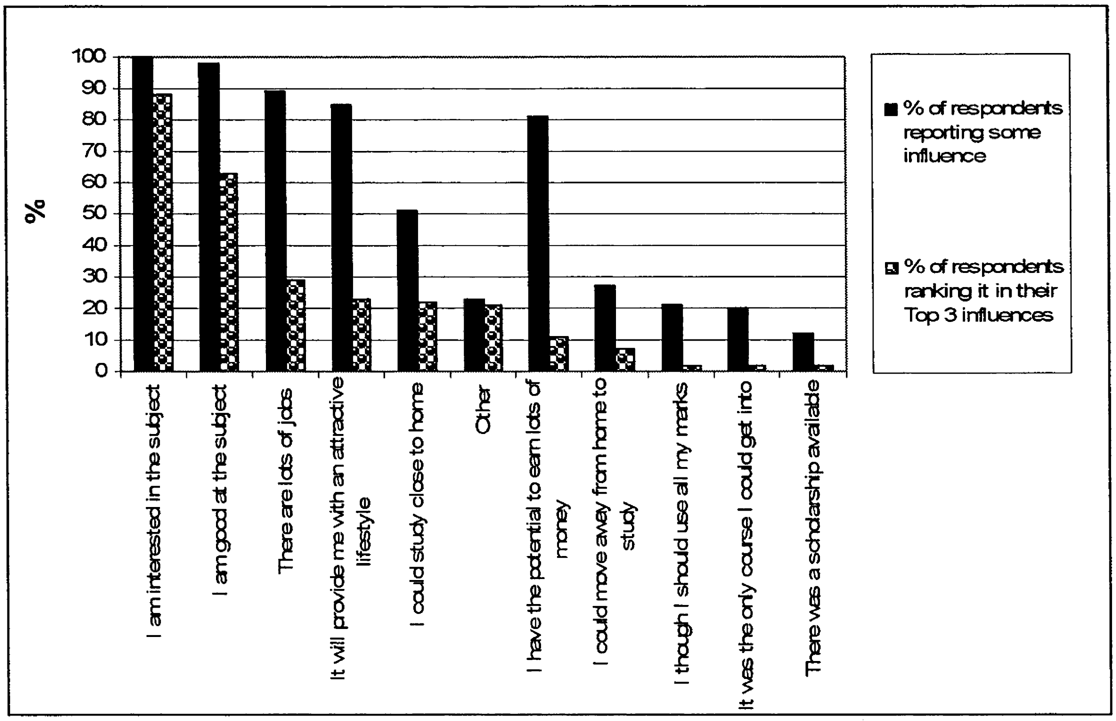


Students chose their course of study because they were interested and good at the subjects (Figure 3). Following interest and ability in the subject, students ranked employment prospects, lifestyle, ability to study close to home and potential remuneration as influencing their career choice.

23% of students surveyed offered "other" reasons for choosing their course of study, citing factors such as career change, the reputation of the institution and altruistic reasons for choosing their course of study. 21% of these students ranked "other" reasons in their Top 3, which may indicate that the prescribed responses in the questionnaire were not a good or true reflection of influences or that "other", unplanned or serendipitous factors require further investigation. Bright et al suggests that unplanned or serendipitous events do influence career decision-making processes. Bright et al reports that these unplanned events are significant and may require focus on "strategies aimed at maximising positive chance experiences and minimising negative chance experiences." [Bright et al, 2005:33]

81% of students surveyed said that the potential to earn lots of money influenced them when they were choosing their course of study, however, only 11% ranked this in their Top 3 influencers. This may indicate that although potential remuneration is important, its significance drops behind other factors such as ability and interest in the subject, job availability, attractive lifestyle, the ability to study close to home and "other" undefined factors.

Figure 3 Student response and rank of influencing statement



Science vs Non-Science

Parents had the greatest influence on science students when they were choosing their career with 86% of them reporting some influence (Table 5). Dr Terry Lyons from the University of New England has explored this phenomenon further and has been reported to say:

> "Parental support is important for students undertaking these 'difficult' subjects. Those opting out of science (and the boys in particular) often lacked supportive relationship with a key parent". [www.une.edu.au/news/archives/000061.htm viewed 23 October 2004]

The influence of the science teacher on prospective science students has also been well documented. Munro and Elsom reported "Science teachers appeared to have a major influence on pupil's motivation toward and employment in science." [Munro and Elsom, 2001:4] Again, this study supports this finding with 82% of science students saying teachers had an influence on them when choosing their course of study (Table 5).

By comparing science with non-science students, we can see the extent to which parents and teachers influence students choosing a career in science. 86% of science students rated parents as an influence compared to 79% of non-science students. Similarly, 82% of science students rated their teachers as an influence compared to 71% of non-science students (Table 5).

Outside family, friends and teachers, science students rated someone already in the field as influencing their decision to choose a career in science (Table 5).

Table 5 Factors influencing student's choice of study: science vs non-science

Influencing Factors	**Science % [n=340]**	**Non-science % [n=148]**
Parents	86	79
Teachers	82	71
Family members	77	75
Somebody already working in the field	69	77
Friends	70	65
Technology	63	52
Career Counsellors	49	44
Internet	45	52
Television	46	47
Newspapers/Magazines	46	46
Radio	30	35
Celebrities	18	26

Teachers had a much greater influence on girls choosing science compared to their counterparts studying something else. For example, 82% of females studying science say their teacher influenced them. This is in comparison to 68% of female non-science students reporting an influence (Table 6).

Table 6 Influence of teachers on career decision: males and females

	Male		Female	
Influencing Factors	Science % (n=130)	Non-science % (n=52)	Science % (n=210)	Non-science % (n=96)
Teachers	82	75	82	68

Technology influenced more science students to choose their course of study compared to non-science students (63% compared to 52%). Unfortunately the term technology was not defined and is open to interpretation. The Internet influenced more non-science students than science students (52% vs 45%

respectively). These results seem contradictory, as you would expect students who are influenced by technology to also be influenced by the Internet.

Table 7 Student response to influencing statement: science vs non-science

Influencing statement	Science % (n=340)	Non-science % (n=148)
I am interested in the subject	100	100
I am good at the subject	98	99
There are a lot of jobs available	89	88
It will provide me with an attractive lifestyle	85	86
I have the potential to earn a lot of money	83	78
I could study close to home	52	49
I could move away from home to study	28	26
It was the only course I could get into	20	21
I though I should use of all my marks [TER]	23	17
There was a scholarship available	15	6

Interest and ability in the subject along with job prospects were the most important factors influencing both science and non-science students (Table 7). However, a greater percentage of the science cohort ranked these factors in their top three, indicating these factors have a greater influence over science students than non-science students (Table 8). As science teachers play an important role in developing a student's aptitude and interest in science, these findings further illustrate the influence science teachers have on prospective science students.

The availability of jobs was more important for science students than non-science students with 33% of the science students surveyed placing job availability in their Top 3 influences compared to 21% for non-science students (Table 8). There was little difference between the two groups for the other influences measured.

Table 8 Top 3 influencing statements: science vs non-science

Influencing statement	Science % (n=340)	Non-science % (n=148)
I am interested in the subject	90 (1)	82 (1)
I am good at the subject	68 (2)	54 (2)
There are lots of jobs available	33 (3)	21
It will provide me with an attractive lifestyle	22	24 (3)
I could study close to home	22	20
Other factors	20	24
I have the potential to earn a lot of money	10	14
I could move away from home to study	6	9
There was a scholarship available	3	1
It was the only course I could get into	2	2
I thought I should use all my marks [TER]	2	1

(Numbers in parenthesis indicate rank)

Male vs Female

Parents, teachers, family members and somebody already working in the field were the most influential factors influencing both males and females when they were choosing their careers.

Technology and the Internet influenced more males than females when they were choosing their career. 70% of males reported that technology had some influence on them compared to 54% of females. This difference becomes even more apparent when you break down males and females into their science and non-science cohort. Here, males studying science were influence the most by technology (72%) and female's not studying science were influenced the least (44%).

Similarly 52% of males said the Internet influenced their career choice compared to 44% of females (Table 9). And, males not studying science were influenced the most by the Internet (59%) and girls studying science were influenced the least (42%).

Table 9 Factors influencing student's choice of study: male vs female

Influencing factors	**Male % (n=182)**	**Female % (n= 306)**
Parents	83	85
Teachers	80	78
Family Members	78	75
Somebody already working in the field	71	72
Friends	70	68
Technology	70	54
Internet	52	44
Television	50	43
Newspapers/Magazines	49	44
Career Counsellors	46	48
Radio	36	29
Celebrities	19	21

Ability and interest in the subject along with job prospects and lifestyle influenced both males and females to the same extent. The potential to earn lots of money influenced more males than females, 89% vs 77% respectively.

Table 10 Student response to influencing statement: male vs female

Influencing statement	Male % (n= 182)	Female % (n= 306)
I am interested in the subject	100	100
I am good at the subject	97	98
There are a lot of jobs available	91	88
It will provide me with an attractive lifestyle	90	83
I have the potential to earn a lot of money	89	77
I could study close to home	52	50
I could move away from home to study	33	24
I thought I should use of all my marks [TER]	29	17
It was the only course I could get into	25	18
There was a scholarship available	16	10

After interest and ability in the subject, job prospects were more important to females with 33% ranking it in the Top 3 influencers compared to 24% of males (Table 11).

Table 11 Top 3 influencing statements: male vs female

Influencing statement	Male % (n= 182)	Female % (n= 306)
I am interested in the subject	83 (1)	90 (1)
I am good at the subject	62 (2)	64 (2)
It will provide me with an attractive lifestyle	25 (3)	21
There are a lot of jobs available	24	33 (3)
Other factors	22	21
I could study close to home	18	24
I have the potential to earn a lot of money	15	9
I could move away from home to study	7	7
It was the only course I could get into	3	2
There was a scholarship available	3	2
I though I should use of all my marks [TER]	3	1

(Numbers in parenthesis indicate rank)

Summary

Of the influencing factors included in this study, it was found that parents and teachers have the greatest amount of influence on students when they are choosing their career. Parents and teachers had a greater influence on students who had chosen to study science, compared to those who had chosen to study something else.

This study also found that a student's interest and ability in the subject and job prospects are the three most influential factors on students when they are choosing their career. These three factors had more influence on science students than non-science students. Students also deemed attractive lifestyle and being able to study close to home important when they were choosing their career. A significant proportion of students said "other" factors had influenced their career decision, which will require further exploration.

Personal relationships and interactions, like those with parents and teachers, were far more influential to students when they were choosing their career compared to non-personal influencers such as the media and celebrities.

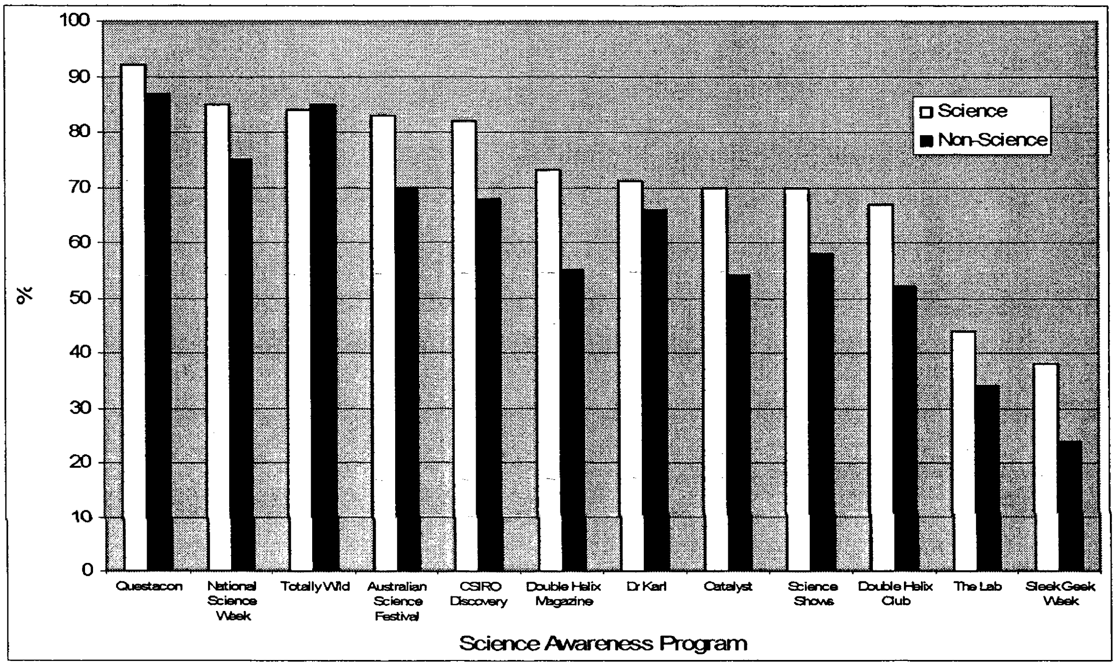
Boys were more influenced by the possibility of earning lots of money, compared to girls. They were also more influenced by technology and the Internet when they were making career decisions. Girls however, were more influenced by job prospects compared to boys. Teachers had the greater influence on girls who were studying science compared to girls who studied something else.

Science awareness programs

It is not the purpose of this study to rank or compare science awareness programs against each other. Because each science awareness program is coordinated by different organisations with a different budget and objectives, this study will report the findings of each program individually.

Having said that, a number of general comments can be made about the science awareness programs. All of the programs included in this research reported some level of awareness amongst the student population. This awareness varied from 91% to 34% (Figure 4). The study found that science students were generally more aware, had participated in, and were influenced more by science awareness programs than non-science studying students.

Figure 4 Awareness of science awareness activities: science vs non-science



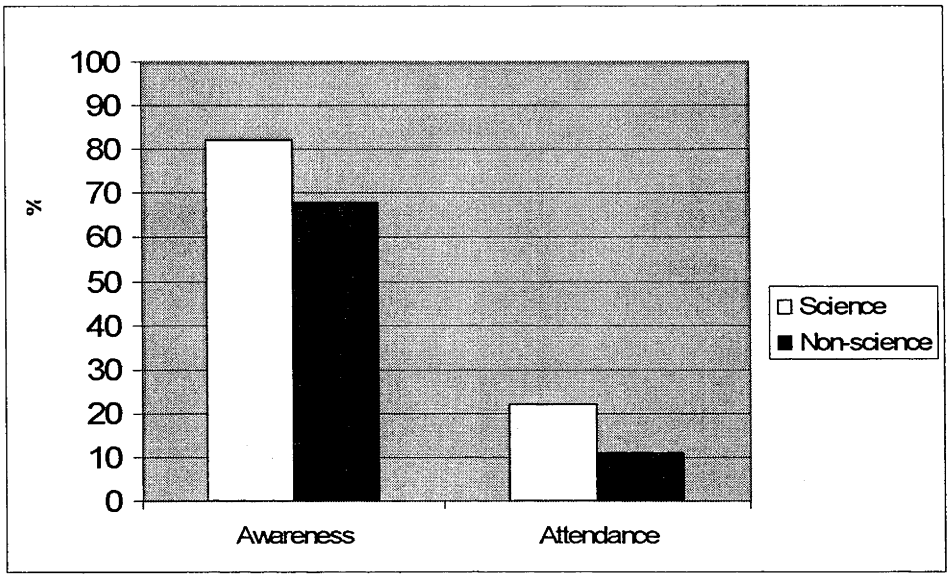
Science Centres

CSIRO Discovery

Science students were more aware and more likely to attend CSIRO Discovery than those students not studying science. 82% of the students studying science were aware of Discovery compared to 62% of non-science students.

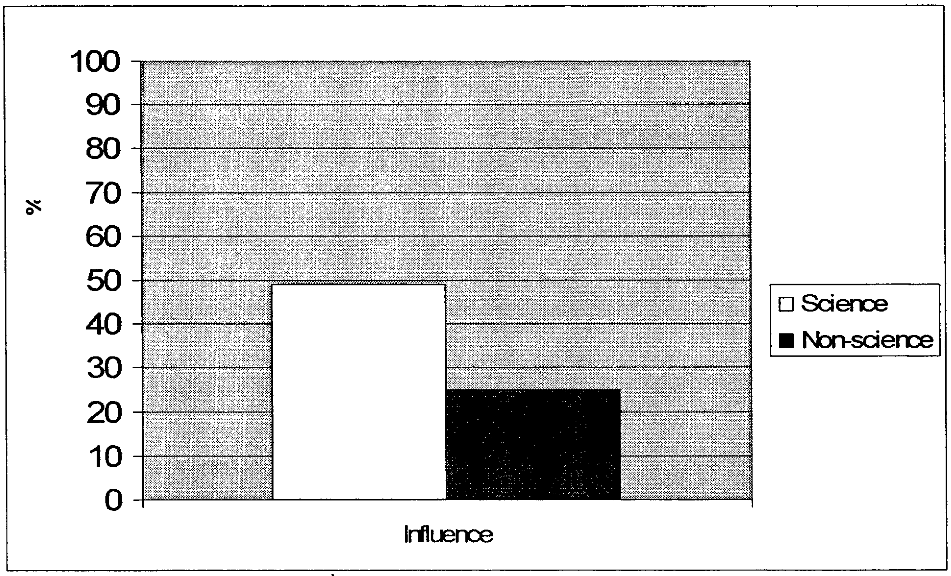
Even though students were aware of CSIRO Discovery, they had not necessarily attended the ACT centre in the past two years. For example, only 22% of science students had been to the centre in the last two years, even though 82% of the students were aware of the centre. (Figure 5)

Figure 5 CSIRO Discovery – awareness and attendance: science vs non-science



Of those science students who had attended CSIRO Discovery in the past two years [n=72], 49% of them said that the experience influenced them to study science (Figure 6).

Figure 6 CSIRO Discovery –influence: science vs non-science



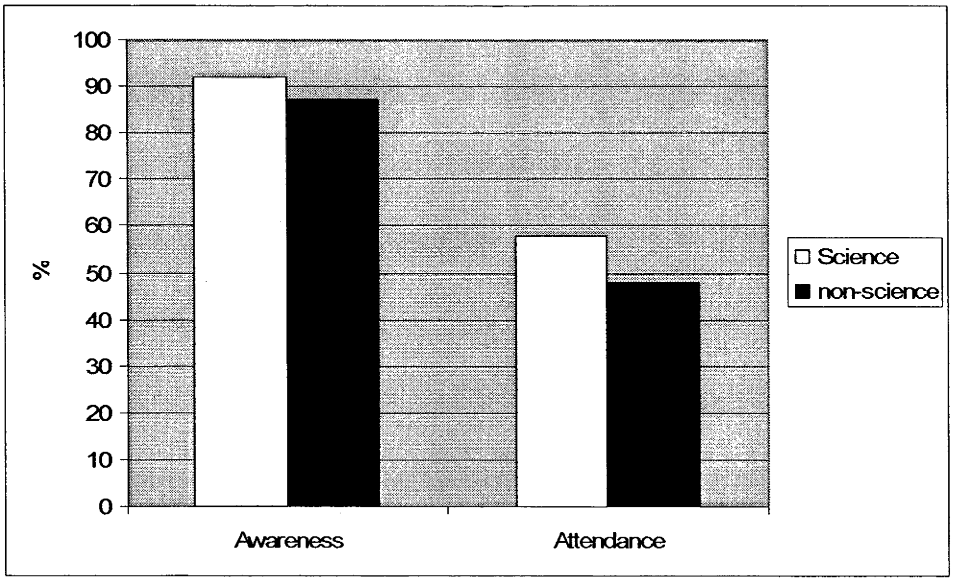
Questacon

91% of students surveyed were aware of Questacon. This level of awareness is across the entire student population, differing little between students studying science and those studying something else (Figure 7).

Students who were studying science were 10% more likely to have visited Questacon than those who weren't studying science. This result is not that surprising as you would expect those students interested in science to attend Questacon. However, what was surprising is that almost half the students who hadn't pursued a career in science still had a Questacon experience. It appears from this result that Questacon is appealing to both science and non-science students.

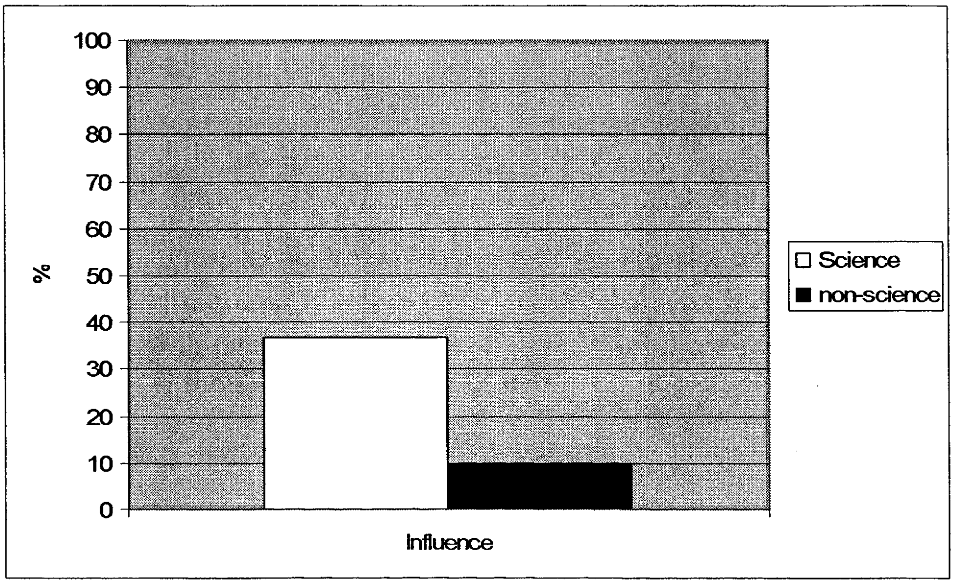
60% of the students surveyed had completed their final year of high school in the ACT, which may have had an impact on the level of awareness and attendance at Questacon, as it is located in the ACT. The survey did show that students who went to high school in the ACT were more likely to have visited Questacon in the last two years, compared to those who attended high school in other areas of Australia (63% vs 54% respectively).

Figure 7 Questacon – awareness and attendance: science vs non-science



Of the students who had been to Questacon (n=186), 37% reported that it influenced them to study science. This level of influence becomes more apparent when you compare it to the 10% of students who said their Questacon experience influenced them to pursue a non-science career (Figure 8).

Figure 8 Questacon – influence: science vs non-science



Science Broadcast

Catalyst

Students who were studying science were more aware, and were more likely to have watched Catalyst, compared to those students not studying science. Figure 9 shows the appeal the television program has to science-inclined students.

Figure 10 shows the extent to which Catalyst influences students to study science. Of the 136 students who watched Catalyst, 49% of them reported that it influenced them to study science.

Figure 9 Catalyst - awareness and attendance: science vs non-science

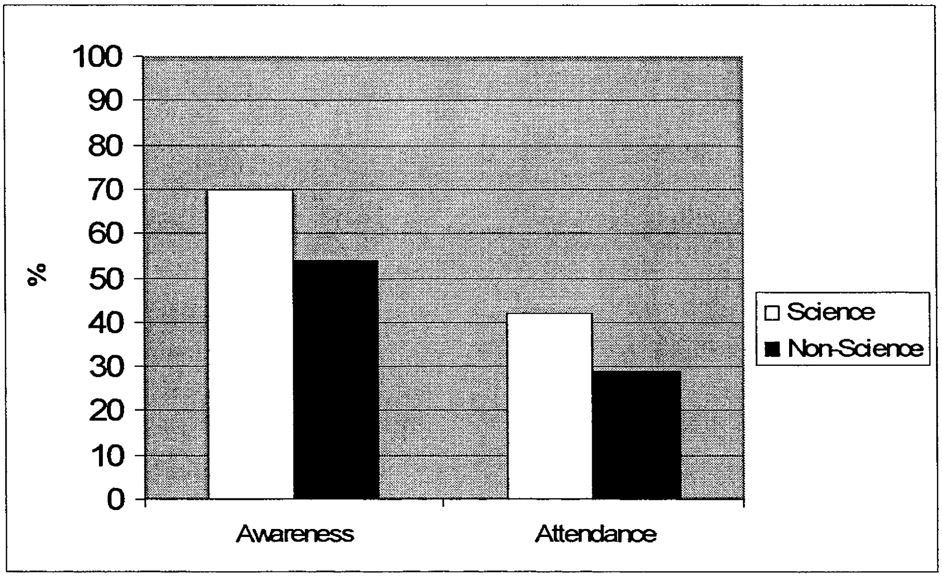
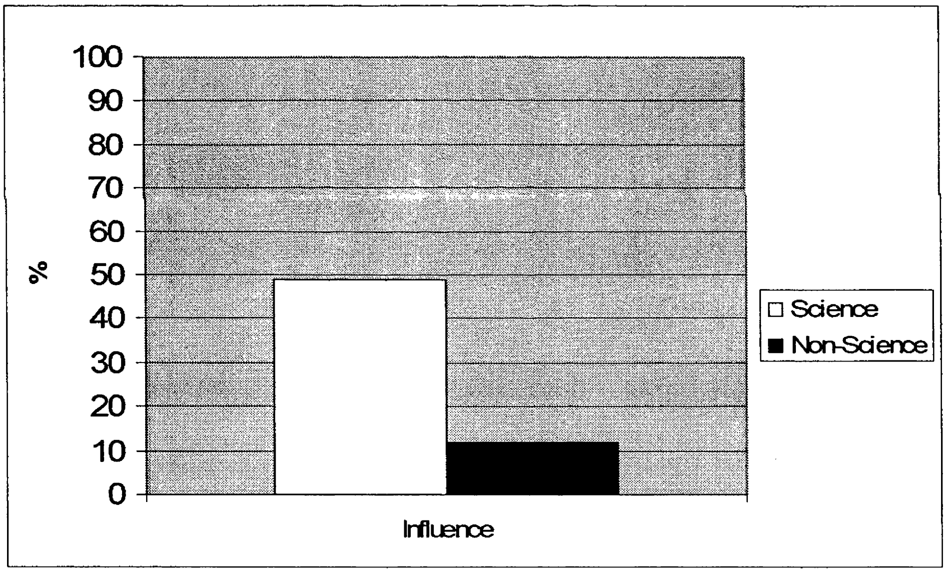


Figure 10 Catalyst - influence: science vs non-science



Dr Karl

70% of those surveyed were aware of Dr Karl and it seems his appeal is not limited to those just studying science. No matter what students were studying, there was a similar level of awareness and had participation in Dr Karl activities (Figure 11)

Figure 11 Dr Karl - awareness, attendance and influence: science vs non-science

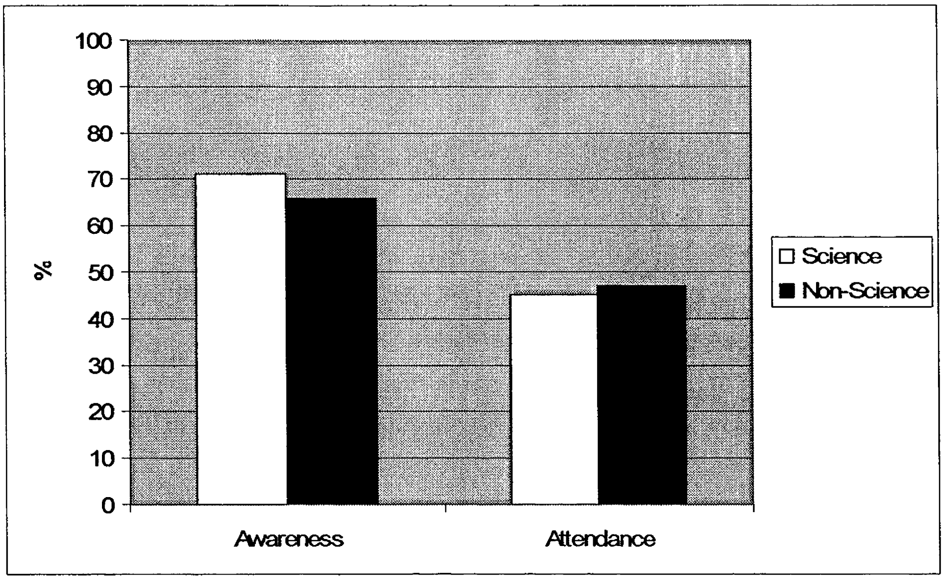
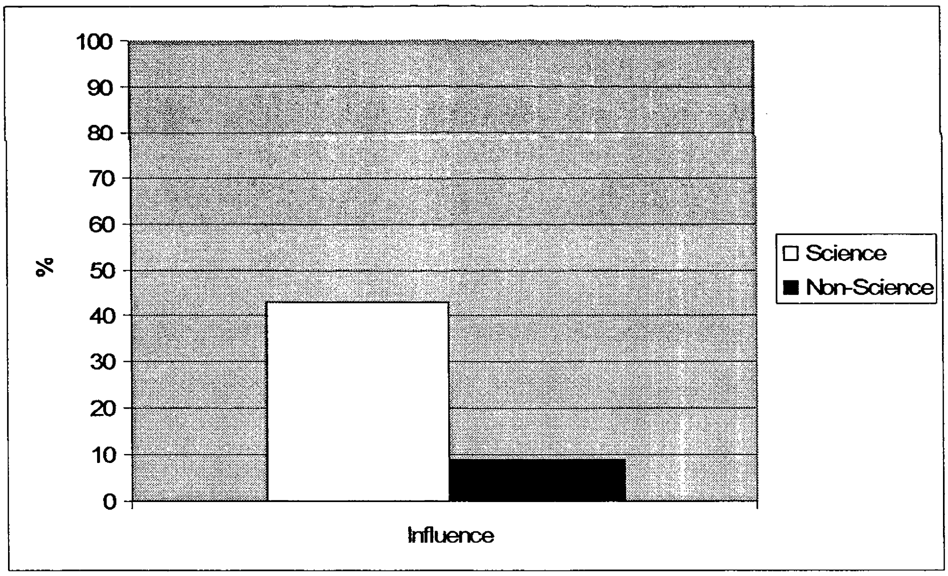


Figure 12 illustrates a difference when we examine the influence Dr Karl has on students when they are choosing their career.

Figure 12 Dr Karl - Influence: science vs non-science



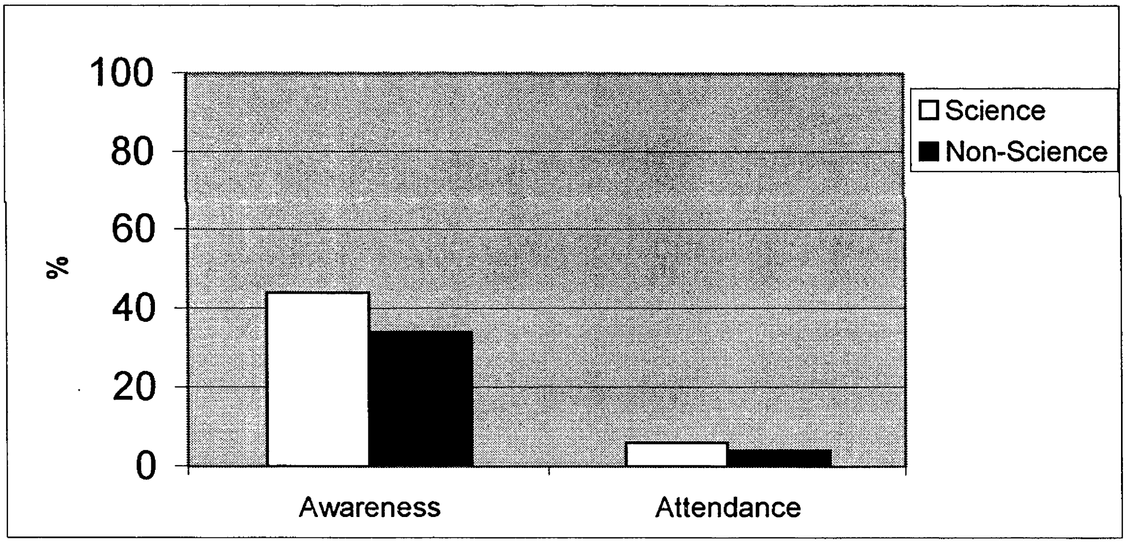
Of the 145 science students who had seen or listened to Dr Karl in the last two years, 43% of them said that he influenced them to study science. This is compared to 9% of non-science students reporting some influence.

The Lab

The majority of students were unaware of The Lab with only 33% of those surveyed reporting they had heard of the on-line ABC Science portal. Figure 13 shows The Lab as having a low level of awareness and attendance amongst both science and non-science students. Figure 13 also illustrates how low awareness results in low participation – which makes sense because if you are unaware of a program, how can you possibly take part.

These results are contradictory to awareness and participation figures that the ABC has collected on The Lab. There may have also been some ambiguity by what was meant by The Lab. It may have been more correct and accurate to refer to the site as ABC Science Online, rather than The Lab.

Figure 13 The Lab - awareness and attendance: science vs non-science



Of the 21 students who had visited The Lab, 12 (58%) reported some influence when they were choosing their career in science. We must be careful when reporting this figure because of the small sample size. The validity of this data is again questionable when you compare it to the influence the program had on students not studying science. Of the 6 students who had visited The Lab, 2

(33%) reported that the experienced influenced them to study a non-science course.

Totally Wild

84% of all students surveyed were aware of Totally Wild and over half of them had watched the show in the past two years.

Figure 14 shows how both science and non-science students were just as likely to be aware and to have watched Totally Wild.

For an activity that had both high awareness and a high level of participation amongst science students, it did not influence as many students to study science as one might expect. 22% of students who had watched Totally Wild (n=167) reported that the show had influenced them in to study science. 10% of non-science students reported some influence (Figure 15).

Figure 14 Totally Wild – awareness and attendance: science vs non-science

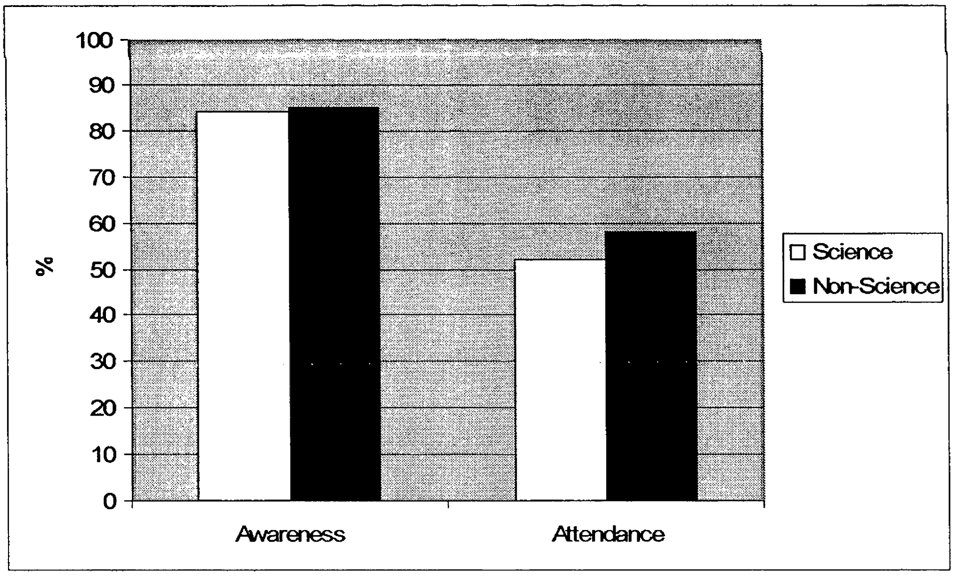
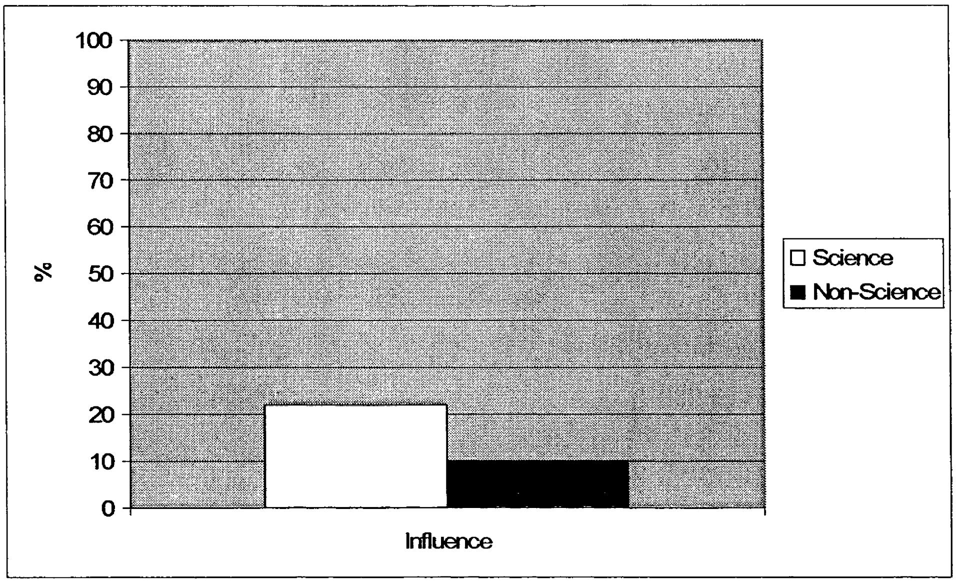


Figure 15 Totally Wild - influence: science vs non-science



Science Events

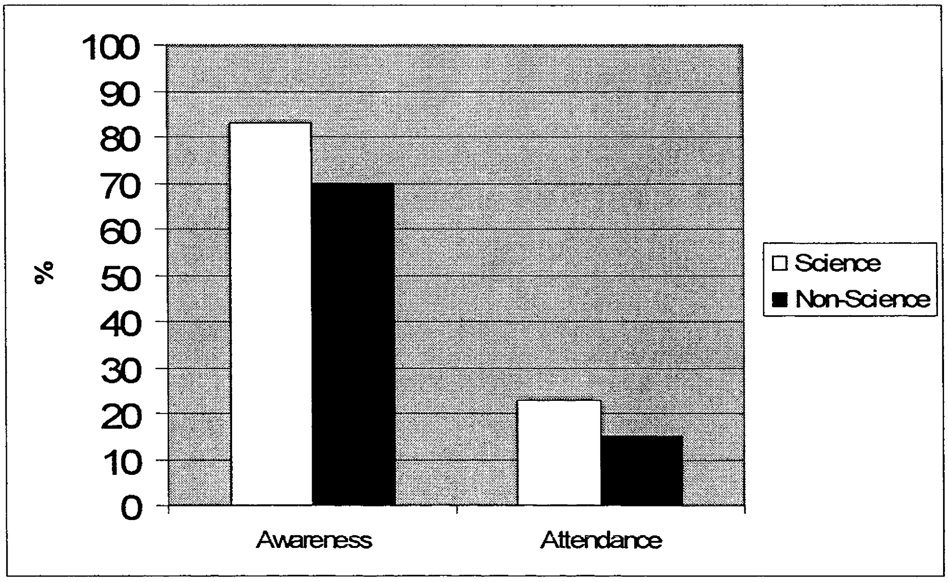
Australian Science Festival

79% of those surveyed were aware of the ACT-based Australian Science Festival. The majority of students were aware of the Festival, irrespective of what course they were studying at university.

Students who completed their final year of high school in the ACT were more aware of the Australian Science Festival than those who had finished school in another state (91% vs 69% respectively). You would expect then, that students from the ACT would have participated in more Australian Science Festival events than those students from outside the ACT. The difference in participation is not that pronounced with 25% of ACT students taking part compared to 16% of students from outside the ACT.

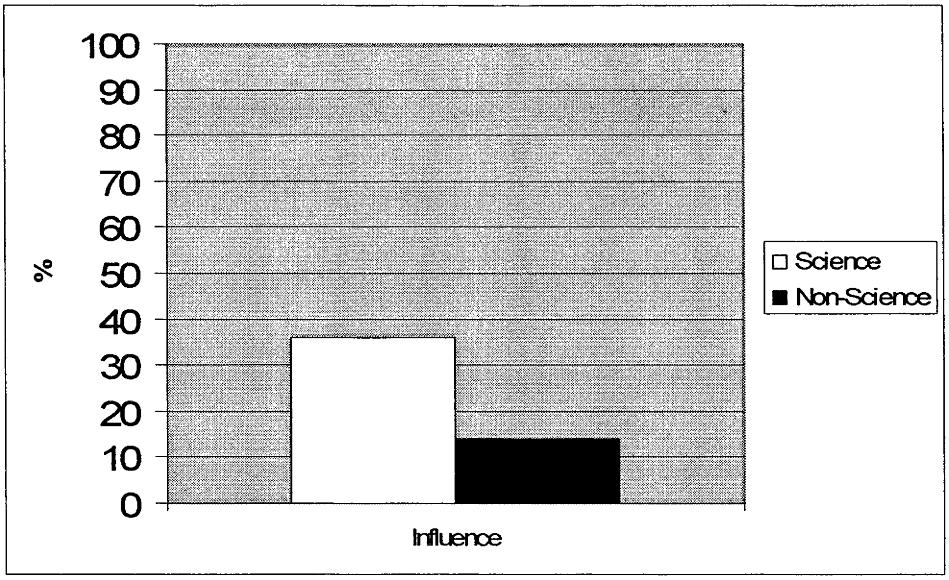
For a program that has such a high awareness across both student groups, and is based in the ACT, the level of participation is surprisingly low (Figure 16). The reason for this may be because the majority of Australian Science Festival events are targeted at lower secondary students, therefore first year tertiary students surveyed may not have had access to the program in the past two years.

Figure 16 Australian Science Festival – awareness and attendance: science vs non-science



Despite these anomalies, of the 76 students who had taken part in the Australian Science Festival, 36% of them reported that the experience had influenced them to study science (Figure 17).

Figure 17 Australian Science Festival – influence: science vs non-science



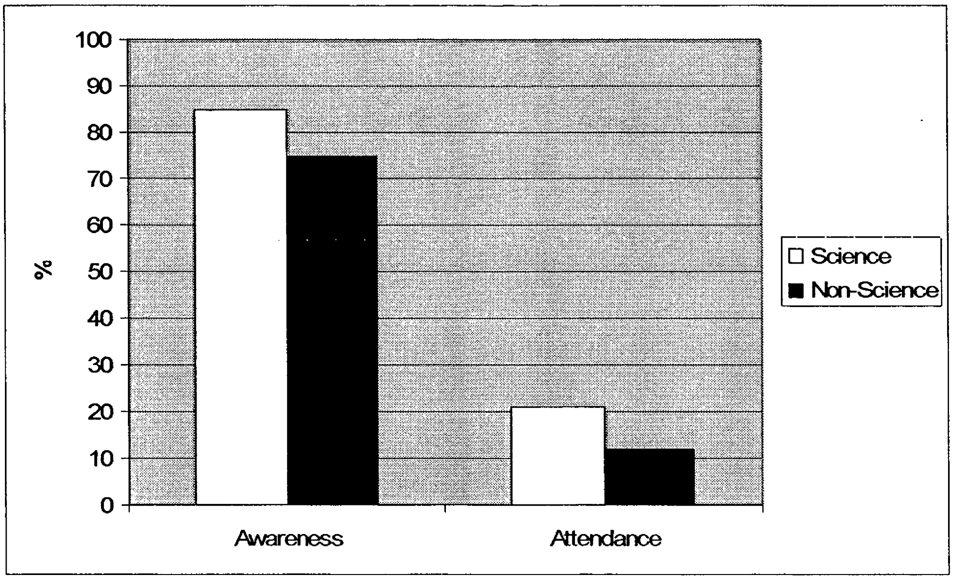
National Science Week

82% of the students surveyed had some awareness of National Science Week. Figure 12 shows how both science and non-science students were aware of this program, with science students being more aware than non-science students (85% vs 75% respectively).

Even though the majority of students were aware of National Science Week, this awareness did not translate into participation in National Science Week activities. For example, 85% of science students were aware of National Science Week, but only 21% of them had participated in a National Science Week activity in the past two years.

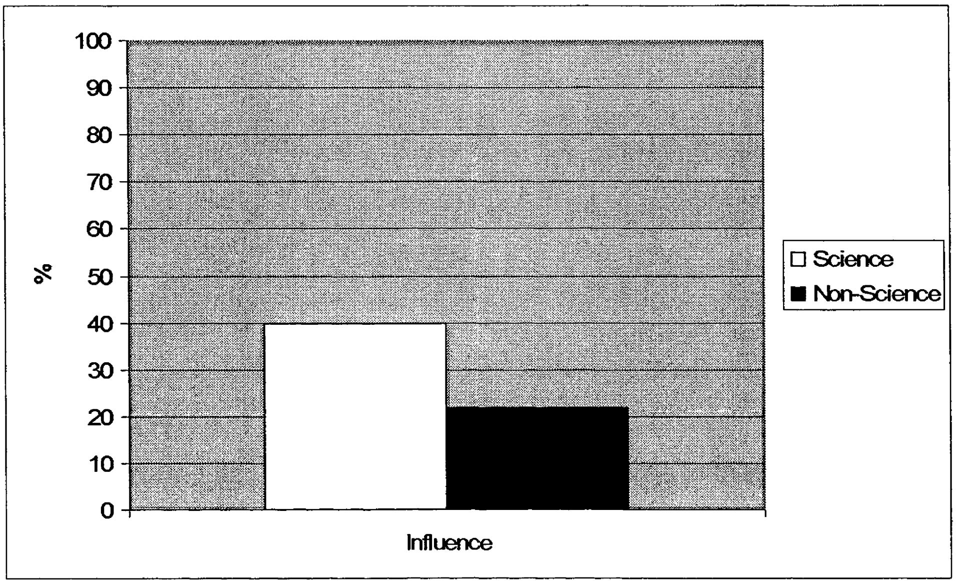
This low participation rate may be because, like the Australian Science Festival, many National Science Week activities are targeted at students in lower secondary school with the aim of encouraging them to study science in Year 11 and 12. As a result, many first year tertiary students would not have been involved in National Science Week activities in the past two years.

Figure 18 National Science Week – awareness and attendance: science vs non-science



Even though participation in National Science Week seems to drop off in the final two years of school, of those students who had attended (n= 70), 40% of them said that the experience influenced them to study science at a tertiary level (Figure 19).

Figure 19 National Science Week – influence: science vs non-science



Science Shows

42% of students studying science were aware of science shows compared to 31% of non-science students (Figure 20). Of the 130 science students who had been to a science show, almost 40% of them said that the experience influenced them to study science (Figure 21).

One of the trends identified in this study is that that awareness of an activity does not necessarily translate into attendance. For example, a lot of people are aware of Catalyst because it is on television, however it does not necessarily mean all of them will watch the show.

Interestingly, for science shows, there appears to be a strong correlation between awareness and attendance. Of the science cohort, 42% were aware of science shows and 38% had attended a science show in the last two years (Figure 20).

Figure 20 Science Shows – awareness and attendance: science vs non-science

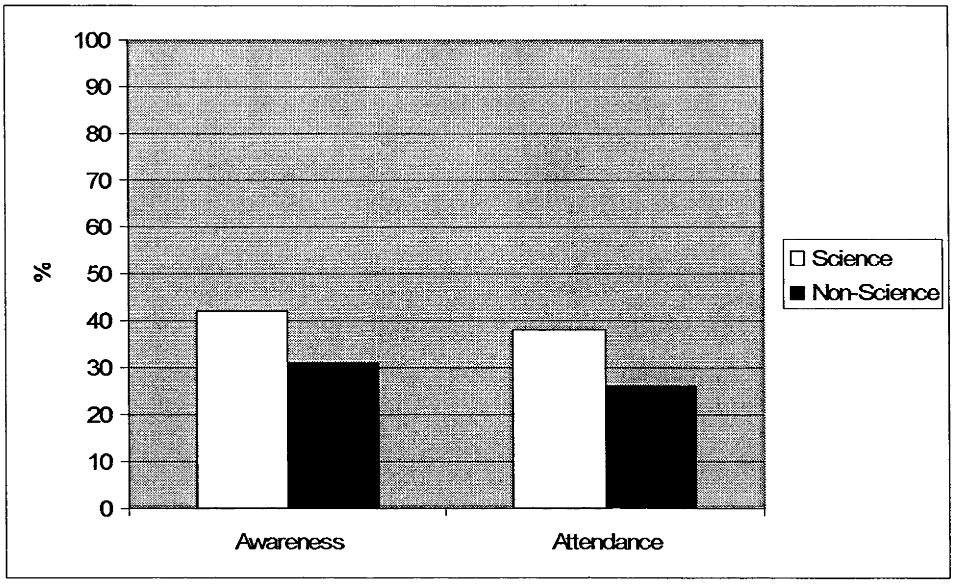
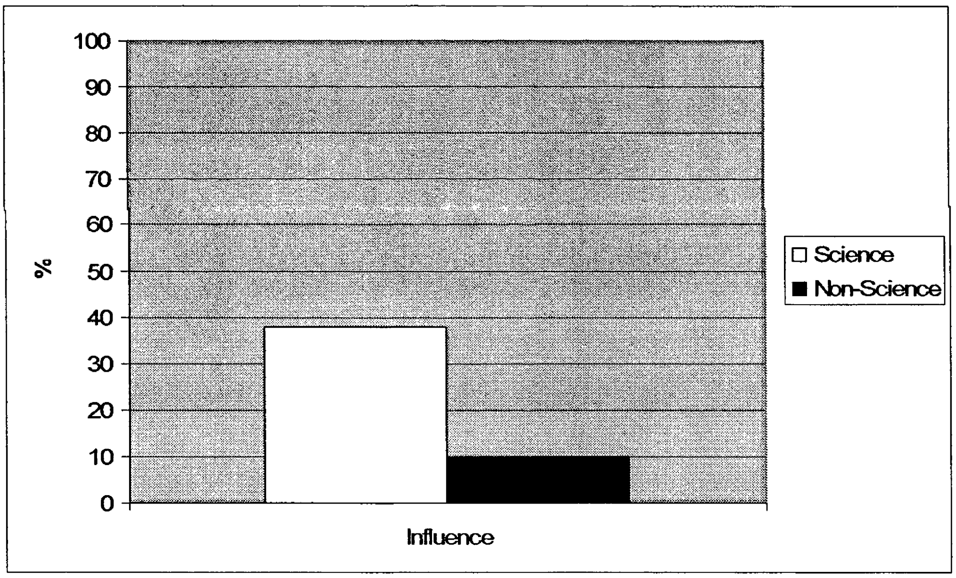


Figure 21 Science Shows – influence: science vs non-science



Science Shows are usually 'grass roots' productions presented in a range of formats and in a variety of locations such as classrooms, local halls, shopping centres, science centres and science festivals. The results may suggest that the awareness of science shows is created by participation in the activity, as opposed to an advertising or promotional campaign.

Sleek Geek Week

Sleek Geek Week has low awareness and participation compared to other science awareness activities evaluated in this study. Of the science students surveyed, 18 had attended the science show in the past two years. This low participation rate in the activity resulted in the program having little influence on students when they are choosing their career.

This low level of awareness and participation is surprising considering the status and popularity of its stars, Dr Karl and Adam Spencer. Sleek Geek Week occurs once a year during National Science Week (and not every year) and is presented in different locations across Australia each time. Because of the programs infrequency the 'Sleek Geek Week' branding may not be as strong as the sum of its parts; namely Dr Karl and Adam Spencer. It would be interesting to see if the awareness of this program was greater if the activity was referred to as "Dr Karl and Adam Spence Annual Science Show".

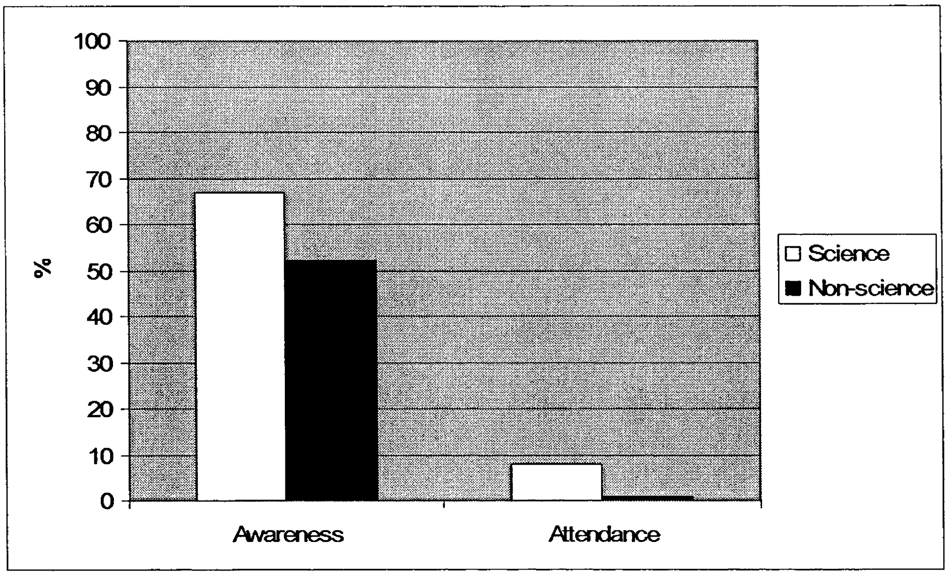
Science Clubs

Double Helix Club

Both science and non-science students were aware of CSIRO's Double Helix Club with 67% of science and 52% of non-science students reporting some level of awareness respectively (Figure 22).

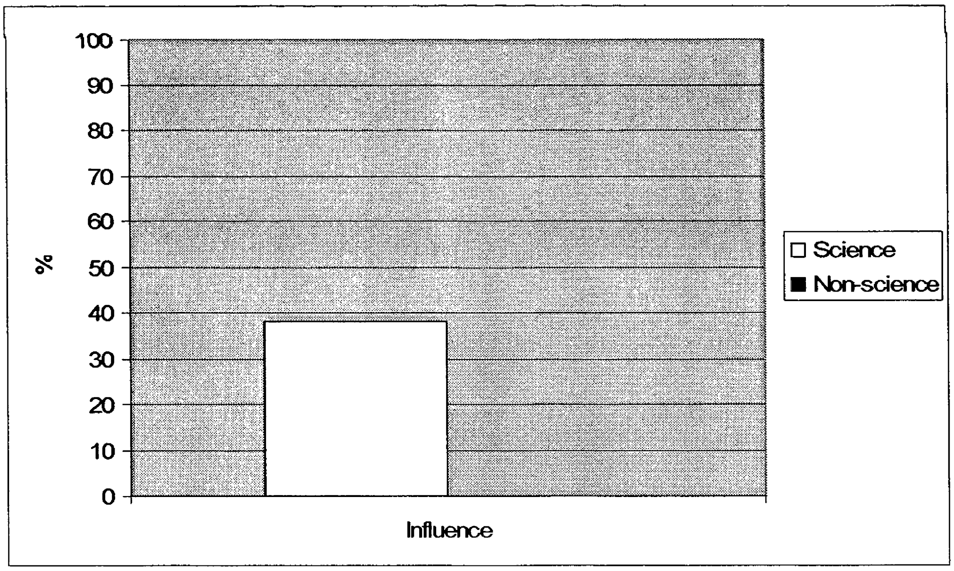
This level of awareness did not translate into attendance in club activities with only 8% of science students and 1% of non-science students having taken part in a Double Helix Club activity in the past two years. This may be because most of the Club activities are targeted to upper primary and lower secondary students.

Figure 22 Double Helix Club – awareness and attendance: science vs non-science



However, of the 26 students who had attended a club activity, 10 of them reported that it had some influence on them when they chose to study science (Figure 23).

Figure 23 Double Helix Club – influence: science vs non-science

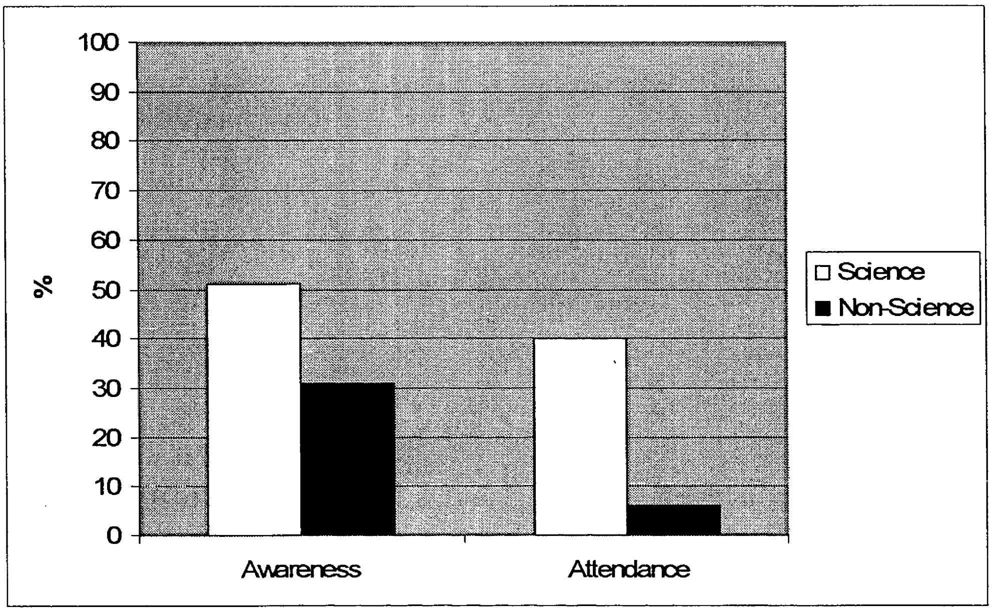


Double Helix Magazine

Those studying science were more likely to be aware of the Double Helix Magazine than those studying something else (51% vs 31% respectively).

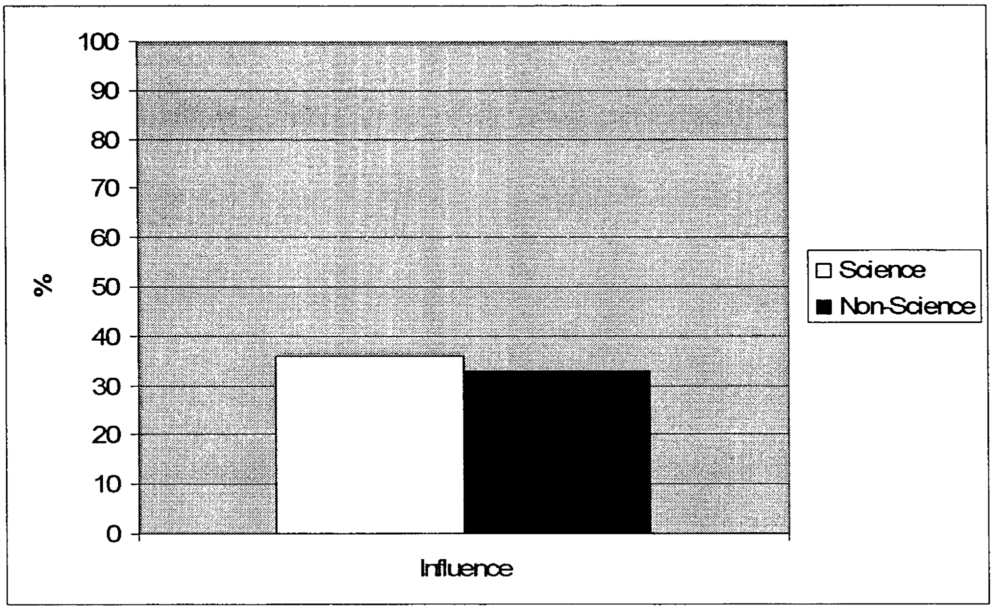
Science students were much more likely to have read a Double Helix Magazine in the past two years.

Figure 24 Double Helix Magazine – awareness and attendance: science vs non-science



Of the 55 science students who had read the magazine, 20 of them said that the experience influence them to study science in some way (Figure 25).

Figure 25 Double Helix Magazine – influence: science vs non-science



Summary

The study showed that students studying science are more likely to be aware and have attended science awareness events than students not studying science.

The study also showed that science awareness programs had some influence on students when they were choosing to study science; and this level of influence varied between the programs (Table 12).

Table 12 Attendance and influence of science awareness programs: science

Science Students			
Science Awareness Program	Total number attended	Total number influenced	% influenced
Science Centres			
CSIRO Discovery	72	35	49
Questacon	186	68	37
Science Broadcast			
Catalyst	136	66	49
Dr Karl	145	63	43
Sleek Geek Week	18	9	50*
The Lab	21	12	57*
Totally Wild	167	37	22
Science Events			
Australian Science Festival	76	27	35
National Science Week	70	28	40
Science Shows	130	50	38
Science Clubs			
Double Helix Club	26	10	38
Double Helix Magazine	55	20	36

*Care must be taken when reporting this figure due to the small sample size

There did not appear to be a strong correlation between a student's awareness and participation in an activity, and the level of influence it had when they were choosing their career. For example, you would expect that the more students are aware and participate in science awareness activities, the greater the influence the program would have on students studying science. This was not a consistent outcome in this study, which may indicate that there are more complex and individual experiences at play in the way a science awareness activity influences a student to study science.

5

Conclusions

Introduction

For some time now, public and private organisations across the globe have been investing significant amounts of money into developing programs that aim to reverse the trend of declining university enrolments in science, particularly enabling sciences such as physics, chemistry and mathematics. The investment is made because of the strongly held belief that for future economic and social prosperity in today's knowledge-economy, a scientifically literate and trained workforce is required.

The review of related literature found that little is known about how successful these science awareness activities are. This is because most of the activities have been poorly or never evaluated and little is known of the effect they have, particularly on their role in influencing students to study science.

To determine the factors that influence students to study science and to see if science awareness activities have a role to play, a questionnaire was given to first year science and non-science tertiary students at ACT institutes.

This chapter views these findings in light of the research questions and provides concluding remarks and recommendations for further research and practice.

What influences students when they are choosing a career in science?

The research found that parents and teachers have a major influence on a those student's who chose a career in science. Considering a student's career choice is usually made when they are under the age of 18, living at home and attending school, this result is not that surprising.

However, it does prompt the question, are parents and teachers properly equipped to provide students with the most accurate and appropriate information about science careers?

With regard to teachers, the Australian Science Teachers Association (ASTA) examination of the current situation via a skills audit of Australian science teachers reports:

> "Teachers do not have the access to stay in touch with current scientific research and career information and hence are not always good public relations machines for science careers or for encouraging students to consider teaching as a realistic career option for that matter".
> [http://www.asta.edu.au/resources/skillsaudit viewed 23/2/2006]

If teachers are providing advice based on their own experience, then they may be unaware of new career opportunities created by changes in technology, government priorities, scientific developments or cultural change. Again, the ASTA report said:

> "It should also be noted that the aging structure of the science teaching workforce with limited knowledge on the emerging fields within science, such as biotechnology and nanotechnology, are going to have difficulty in providing the type of information and enthusiasm about these fields that would entice students to pursue rewarding careers in science."
> [http://www.asta.edu.au/resources/skillsaudit viewed 23/2/2006]

If parents and teachers are not appropriately equipped to provide career advice, then the school career councillor, by definition, should be equipped with information to guide students in their decision making. However, this study showed that career councillors had little influence on students when making their career decision.

The study also found that a student's career choice can be influenced by somebody already working in the field. Little is known about these relationships and how they are formed and maintained. It does suggest, however, that increasing the opportunity for these relationships to form by strengthening the linkages between school and industry, could play an important role in encouraging science careers.

The study found that students are more likely to choose a career in science because they enjoy it and are good at it. This finding further confirms the importance of both parents and teachers on a student choosing, or conversely, not choosing a career in science. The role of the family and teachers in nurturing aptitude and confidence in a subject can have a direct influence on a student choosing that area of study for a career.

The important role the teacher plays in influencing students to study science has been demonstrated in this study. The review of literature in Chapter 2 showed that the state of science teaching in Australia is less than ideal; little time is dedicated to teaching science in the early schooling years and it is predicted that there will be major shortfalls in the number of suitably qualified teachers in the enabling sciences in the near future, particularly in rural areas. This is a worrying development that may have already affected the rate at which students are choosing science as a career. There have been many groups and organisations calling for measures to reverse this trend, including ASTA who would like to see greater recognition of the value of the professionally trained science teacher which is reflected in career path and remuneration; focus on improving the science-literacy in the community which in turn would raise the profile and appreciation of the science teacher; and employment initiatives to increase the number of qualified teachers in physics, chemistry, maths and molecular biology. [http://www.asta.edu.au/resources/skillsaudit viewed on 23/1/2006]

The study showed that students chose their career based on the quality of life they believe it will provide them. Students ranked job availability, attractive lifestyle and potential remuneration as factors that influenced them in making their career decisions. Students appear to be basing their career decision not only on the day-to-day activity of the job, but also the benefits and satisfaction they believe it will provide in their after-work life. This result indicates that students also require accurate information on future job prospects, where those jobs will be, potential career development and how much they will be paid.

The outcomes reported here show that student's are influenced by inter-personal relationships and lifestyle choices when they are choosing a career in science. This information is important when designing science awareness activities to help promote science as a career. The results indicate that instead of producing another book, CD, video or brochure to promote science as a career, effort is required in equipping parents and teachers with appropriate knowledge and skills, introducing measures to improve the quality of science teaching and encouraging linkages between schools and industry.

The following section will report on the success of existing science awareness activities designed to promote science as a career, and will draw upon all the research finding to make recommendations.

Do science awareness activities influence students to study science?

The study found that science students were aware and had participated in all of the science awareness activities examined. Science students were usually more aware and more likely to have participated in a science awareness activity, compared to those students who were not studying science.

The extent of a student's awareness and participation in science awareness programs varied between programs, and between program types. This result is not surprising considering the science activities investigated in the research are produced by different organisations (some volunteers), they have different budgets, they draw from varying expertise, they are presented in different formats, some are year-round activities and others are seasonal.

The study found that science awareness activities influenced students to study science. Again, the level of influence varied between programs and program types. For some programs, over 50% of students reported the experience to have influenced them to study science.

From the results of the research, there did not appear to be a strong correlation between awareness of an activity and participation in it. Awareness of a program may indicate the success of an advertising campaign and does not necessarily mean that students will take part in the program.

Similarly, there did not appear to be a strong correlation between participation in a program and the influence it had on students to study science. Again, the level of participation in a science awareness activity may be measure of its accessibility, and did not provide evidence to suggest influence or change of behaviour has taken place. This result suggest that there are other factors at play that determine if a program is successful in influencing students to study science. Just because a program is popular does not necessarily mean it is successful in encouraging science careers.

This is an important finding, as the success of many science awareness programs are determined by their level of awareness within the community, and how many people have participated in them. This research suggests that awareness of, and participation in a science awareness activity is not the most accurate way to determine if they have influenced or changed the behaviour of participants.

To date, science communication research has been vastly under-funded.

> "Despite the recognition of the many ways of which festivals, science centres, public organisations.....the media, the internet and so on are affecting public awareness in a positive and enjoyable way, the task of defining what they are doing and why they "work" – or even whether they work – is not addressed. [Stocklmayer 2001:146]

It is hoped that the outcomes of this research, which shows science awareness activities do influence students to study science, will be a strong basis upon which further science communication research can be justified. Now that there is evidence to suggest that science awareness activities are playing a role in influencing students to study science, further research is required to determine how, when and to what extent this is occurring.

Limitations

Due to the prescriptive nature of a questionnaire, both science and non-science students reported "other" factors as influencing their career decision. This may indicate one of two things: the prescribed responses were not a good or true reflection of influences or that "other", unplanned or serendipitous factors require further investigation. Either way, this result must be taken into consideration for further research where more in-depth qualitative research can drill-down to discover more about these "other" factors, and their importance.

Because ACT-based science awareness activities were chosen to be used in this research, extrapolation of the results to other states in Australia may be limited. The Australian Science Festival, CSIRO Discovery and Questacon are all based in the ACT, and the majority of the students surveyed were from the ACT, which could present an element of bias.

Recommendations

In light of the outcomes of the research, the following recommendations are made.

1. Further investigation into the genesis of career decisions

Although this study does demonstrate that a student is more likely to choose a career because they are good at it and enjoy it, it doesn't determine how or when this ability and interest originated. We assume that both parents and teachers have a role in nurturing interest and ability, but we do not know who or what factors are responsible for creating it, maintaining it and developing it into a career. For example, are children just born with an inherent leaning toward a discipline or career; can a chance experience in their early years determine what they are going to study; what are all the factors that lead to that career choice? Further research into what determines a child's interest or ability in a career and how or when it was developed or lost, would be a useful tool in fully understanding what influences students to study science.

2. Further investigation into how science awareness programs influence career decisions.

There is now evidence to suggest that science awareness programs do influence students to study science and that some programs do this more successfully than others. Further in-depth research is required to determine how these activities influence students to study science. This information could then be used to:

a. develop strategies to minimise the variation of outcomes between programs, and maximise positive behavioural change,

b. develop meaningful ways of evaluating science awareness programs, and

c. assist in developing a 'code of best practice' that could be implemented when developing science awareness activities.

3. Increase parent and teacher participation in science awareness activities

The research has shown the influencing role parents and teachers have on students studying science. This provides evidence to suggest that parent and teachers should be involved in science awareness programs, a strategy not actively used in science awareness activities today. Examples of how this could be done include: 'Parent and Scientist Nights' – encouraging engagement between working scientists and parents, and 'Adopt-a-Scientist' – encouraging scientists' presence in the classroom, acting as a mentor for the teacher and scientific expert to students.

4. Encourage industry – school linkages

Considering the influence people already working in the field can have on students when they are choosing their career, it seems logical to increase the linkages between industry and schools. This could take the form of in-service opportunities for teachers to experience the world of science outside the classroom; cadetships, mentoring programs and summer scholarships for students; or specialist branches of industry to work with schools to introduce emerging fields of science.

To encourage industry 'buy-in', further research may be required into how these relationships form, how they are maintained and in exactly what way they influence students to study science.

In conclusion, this study has answered the research questions and made recommendations based on the outcomes of the research. The study found that parents, teachers and people already working in the field were most influential on students choosing a career in science. The study also demonstrated that science awareness activities do influence students to choose a career in science.

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Appendix

Appendix 1

Why do you do what you do?

The information collected in this questionnaire will assist career guidance initiatives of various organisations and university faculties.

I am aware that the information provided in this questionnaire is for research purposes only.

Please initial here: ____________________
Date: ____________________

1. In what area have you chosen to study? ***(Please tick)***

Biological Science ☐
Physical Science ☐
Business/Economics ☐
Arts ☐
Engineering ☐
Other ☐ Please specify______________________________

2. Where did you complete your final year of high-school? ***(Please tick)***

ACT ☐ NSW ☐ QLD ☐ VIC ☐ SA ☐ TAS ☐
WA ☐ NT ☐ Overseas ☐

3. How old are you? ***(Please tick)***

18 – 25 ☐
26 – 35 ☐
36+ ☐

4. Are you: ***(Please tick)***

Male ☐
Female ☐

5. Please show how much influence you think the following factors had on your choice of study *(Please circle)*

	Very strong influence	Strong influence	Some influence	Little influence	No influence
Friends	1	2	3	4	5
Teachers	1	2	3	4	5
Career Counsellor	1	2	3	4	5
Parents	1	2	3	4	5
Family members	1	2	3	4	5
Television	1	2	3	4	5
Celebrities	1	2	3	4	5
Newspapers/Magazines	1	2	3	4	5
Radio	1	2	3	4	5
Internet	1	2	3	4	5
Technology	1	2	3	4	5
Someone already working in the field	1	2	3	4	5

6. How much do the following statements reflect why you chose your course to study?*(Please circle)*

	Very strong	Strong	Some	Little	No
I am interested in the subject	1	2	3	4	5
I am good at the subject	1	2	3	4	5
There are a lot of jobs available	1	2	3	4	5
I have the potential to earn a lot of money	1	2	3	4	5
It will provide me with an attractive lifestyle	1	2	3	4	5
It was the only course I could get into	1	2	3	4	5
I thought I should use all my marks (TER)	1	2	3	4	5
There was a scholarship available	1	2	3	4	5
I could study close to home	1	2	3	4	5
I could move away from home to study	1	2	3	4	5

Were there any other factors you think influenced you? *(Please specify)*

____

____

7. Please rank in order the top three factors that influenced your study choices the most. ***(Please number 1 to 3. 1 having the most influence)***

☐ I am interested in the subject
☐ I am good at the subject
☐ There are a lot of jobs available
☐ It was the only course I could get into
☐ It will provide me with an attractive lifestyle
☐ I could study close to home
☐ I thought I should use all my marks (TER)
☐ I have the potential to earn a lot of money
☐ I could move away from home to study
☐ There was a scholarship available
☐ Other factors

8. How aware are you of the following? ***(Please circle)***

	Very strong awareness	Strong awareness	Some awareness	Little awareness	No awareness
Dr Karl	1	2	3	4	5
CSIRO Discovery Centre	1	2	3	4	5
Australian Science Festival	1	2	3	4	5
Double Helix Magazine	1	2	3	4	5
Totally Wild	1	2	3	4	5
Double Helix Club	1	2	3	4	5
Questacon	1	2	3	4	5
The Lab	1	2	3	4	5
Catalyst	1	2	3	4	5
Sleek Geek Week	1	2	3	4	5
National Science Week	1	2	3	4	5
Science Shows	1	2	3	4	5

9. How much influence did the following factors have on your choice of studies? *(Please circle)*

	Very strong influence	Strong influence	Some influence	Little influence	No influence
National Science Week	1	2	3	4	5
The Lab	1	2	3	4	5
Australian Science Festival	1	2	3	4	5
CSIRO Discovery Centre	1	2	3	4	5
Totally Wild	1	2	3	4	5
Double Helix Club	1	2	3	4	5
Questacon	1	2	3	4	5
Dr Karl	1	2	3	4	5
Catalyst	1	2	3	4	5
Double Helix Magazine	1	2	3	4	5
Sleek Geek Week	1	2	3	4	5
Science Shows	1	2	3	4	5

10. Have you attended, listened or watched any of the following activities or events in the past two years? *(Please tick)*

	Yes	No
Dr Karl	☐	☐
Science Shows	☐	☐
Totally Wild	☐	☐
Australian Science Festival	☐	☐
Double Helix Magazine	☐	☐
The Lab	☐	☐
CSIRO Discovery Centre	☐	☐
Questacon	☐	☐
Sleek Geek Week	☐	☐
Catalyst	☐	☐
National Science Week	☐	☐
Double Helix Club	☐	☐

Thank you